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ABSTRACT

This instructor's guide is intended for use in teaching the agricultural mechanics unit of a plant science core curriculum. Covered in the individual units of the guide are the following topics: arc welding (following safety procedures, controlling distortion, selecting and caring for electrodes, identifying the material to be welded, and welding in horizontal and vertical positions); oxy-acetylene welding (following safety practices, fusion welding, brazing metal, and heating metal); power tools; painting; tool sharpening and reconditioning (reconditioning wood chisels, plane irons, center punches, and chain saws); cold metal work; and material selection, plan reading, and plan interpretation. The introductory section of the guide contains a list of behavioral objectives, suggested motivational techniques and interest approaches, a list of references and materials, suggestions for evaluating student performance, a work schedule for agricultural mechanics in plant science, and a time allotment for agricultural mechanics skills in animal science and plant science. Included in the individual lessons are objectives, study questions, a list of references, a detailed teaching outline, an evaluation instrument, and answers to the evaluation instrument. (MN)

AGDEX 710

INSTRUCTOR'S GUIDE

ED235310

AGRICULTURAL MECHANICS UNIT

FOR

PLANT SCIENCE CORE CURRICULUM

Richard E. Linhardt
Associate Professor
Agricultural Education
University of Missouri-Columbia

Bill Hunter
Research Assistant
Instructional Materials Laboratory
University of Missouri-Columbia

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ACKNOWLEDGMENTS

The Agricultural Mechanics Unit for the Plant Science Curriculum has been developed to supplement the materials in the Agricultural Mechanics Unit for Animal Science. This material consists of seven units which emphasize skill development. The format of the lessons involved should facilitate lesson planning for teachers.

Special recognition is due to the Agricultural Mechanics Curriculum Advisory Committee who contributed guidance on the content of this unit. Members of the committee included vocational agriculture instructors: Perry Brooks, Columbia; Gene Eulinger, Lathrop; Ed Hagerman, Bolivar; Russel Ramsey, Fredericktown; Jim Schulze, Troy; Darrel Strain, Alton; and Tom Toellner, Boonville; and G. W. Hamby, District Supervisor, Agricultural Education, Department of Elementary and Secondary Education.

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Bill Hunter, Research Assistant
Instructional Materials Laboratory
University of Missouri-Columbia

Richard E. Linhardt, Associate Professor
Agricultural Education
University of Missouri-Columbia

FOREWORD

This unit of instruction in Agricultural Mechanics is an important revision to the Plant Science Curriculum available in Vocational Agriculture. This revision has been a high priority item in the Plant Science Curriculum currently being taught in Missouri agriculture programs.

Teachers should make every effort to keep the lessons practical and to provide laboratory instruction in the basic skills of Agricultural Mechanics.

This unit of instruction in Agricultural Mechanics is to be a part of the curriculum in Plant Science. The Agricultural Mechanics Unit in Plant Science is designed to build on the basic skills developed in the Animal Science course.

References listed are not all required but are listed for the convenience of the teacher. Some of the references are out of print but are popular in schools so teachers may wish to refer to the bibliography for alternate sources.

Curtis R. Weston, Coordinator
Agricultural Education
University of Missouri-Columbia

Larry Case, Director
Agricultural Education
Department of Elementary and
Secondary Education

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AGRICULTURAL MECHANICS UNIT
FOR
PLANT SCIENCE CORE CURRICULUM

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PLANT SCIENCE

Unit - Agricultural Mechanics

OBJECTIVES:

At the end of this unit, the student will be able to:

1. Arc weld metal in the horizontal and vertical positions.
2. Fusion weld with oxy-acetylene in the flat position.
3. Braze weld with oxy-acetylene in the flat positon.
4. Use power tools safely and precisely.
5. Spray paint objects, using correct surface preparation, paint preparation, and spray gun techniques.
6. Sharpen or recondition wood chisels, plane irons, center punches, and chain saws.
7. Use cold metal skills such as hacksawing, filing, bending, and riveting in the construction of a small metal project.
8. Select the proper materials and use them for project construction.
9. Read and interpret project plans and working drawings.
10. Utilize agricultural mechanics skills in this unit in project construction.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH:

1. Display in the front of the classroom examples of the skills that the students will perform by the end of the unit.
2. Ask the students how many of them have shops at home. Have these students identify pieces of equipment and tools in their shops at home. Relate the skills that the students will perform to the tools and equipment in the home shop.

UNITS:

1. Arc Welding
2. Oxy-acetylene Welding
3. Power Tools
4. Painting
5. Tool Sharpening
6. Cold Metal Work
7. Material Selection, Plan Reading, and Interpretation
8. Project Construction

GETTING READY FOR THIS UNIT

A. References and Materials:

The references and materials listed below are only suggestions. This does not imply that they must all be used. Using any of the suggested texts and a selection of the other materials should be sufficient to successfully teach the unit.

1. Automotive Refinishing Guide. Cleveland, OH: Sherwin-Williams Company, 1979.

2. Bear, W. Forrest, William H. Hamilton, and Arthur Mann. Planning Project Construction. St. Paul, MN: Hobar, 1974.

3. Ditzler Automotive Finishes. Ditzler Repaint Manual. Troy, MI: PPG Industries, 1976.

4. FOS - Welding. 2nd ed. Moline, IL: Deere and Company, 1974.

5. Getting the Most Out of Your Band Saw. Pittsburgh, PA: Power Tool Division, Rockwell International, 1978.

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7. Giachino, J. W., William Weeks, and Elmer Brune. Welding Skills and Practices. 4th ed. Chicago: American Technical Society, 1971.

8. Hoerner, Thomas A. and Mervin D. Bettis. Power Tool Safety and Operation Instructor's Packet. St. Paul, MN: Hobar, 1973.

9. Instructor's Manual for a Basic Course: Oxy-acetylene Brazing, Cutting, and Welding. Minneapolis, MN: Smith Equipment Division of Tescom Corporation, 1967.

10. Irvin, Daniel W. Power Tool Maintenance. New York: McGraw-Hill, 1971.

11. Jones, Mack M. Shopwork on the Farm. 2nd ed. New York: McGraw-Hill, 1955.

12. The Oxy-Acetylene Handbook. 3rd ed. New York: Linde Division-Union Carbide Corporation, 1976.

13. Shinn, Glenn C., and Curtis R. Weston. Working in Agricultural Mechanics Student Text. New York: McGraw-Hill, 1978.

14. Structures and Environment Handbook. 10th ed. Ames, IA: Midwest Plan Service, 1978.

15. Wakeman, T. J. Modern Agricultural Mechanics. Danville, IL: Interstate, 1977.

B. Advance Arrangements

Become familiar with the agricultural mechanics needs of each student's supervised occupational experience program. Throughout these lessons focus on solving real problems that the students will face at home and on the job.

EVALUATION:

1. Give short objective tests following each lesson and at the conclusion of the unit.

2. Look for evidence of growth of students in their ability to use the background learned in earlier agricultural mechanics instruction to solve problems in these units.

3. Observe students' attempts to solve similar problems in their own supervised occupational experience programs.

WORK SCHEDULE FOR AGRICULTURAL MECHANICS IN PLANT SCIENCE

The work schedule for agricultural mechanics skills in the Plant Science Course is difficult to arrange. However, the following steps should help the teacher in arranging the shop and in organizing the student to maximize the learning of basic skills in agricultural mechanics.

1. Observe and write down the major areas of the shop that fit the Plant Science Course.

2. Develop and assign skills for each area.

3. Assign time allotment for each area and skill according to the Lab Periods Chart.

4. Align the number of skills with the amount of time in the unit.

5. Determine the number of students that can reasonably be admitted in the class to maximize learning.

6. Assign each student a schedule of activities as listed on the Lab Period Chart.

7. Arrange the master schedule on the Lab Chart so that each student will be rotated at the appropriate periods.

NOTE: Each skill must be designed so the student has a reasonable probability of completing the work on time and meeting a standard of performance. Each student should learn early in the year the appropriate rates and standard of performance expected. See schedule on next page.

A Time Allotment Chart has also been included that shows how agricultural skills in the Animal Science Course and Plant Science Course work together.

Following the Time Allotment Chart is a sample grading chart for recording student scores for each exercise.

Lab Periods

Student's Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	16	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	4	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
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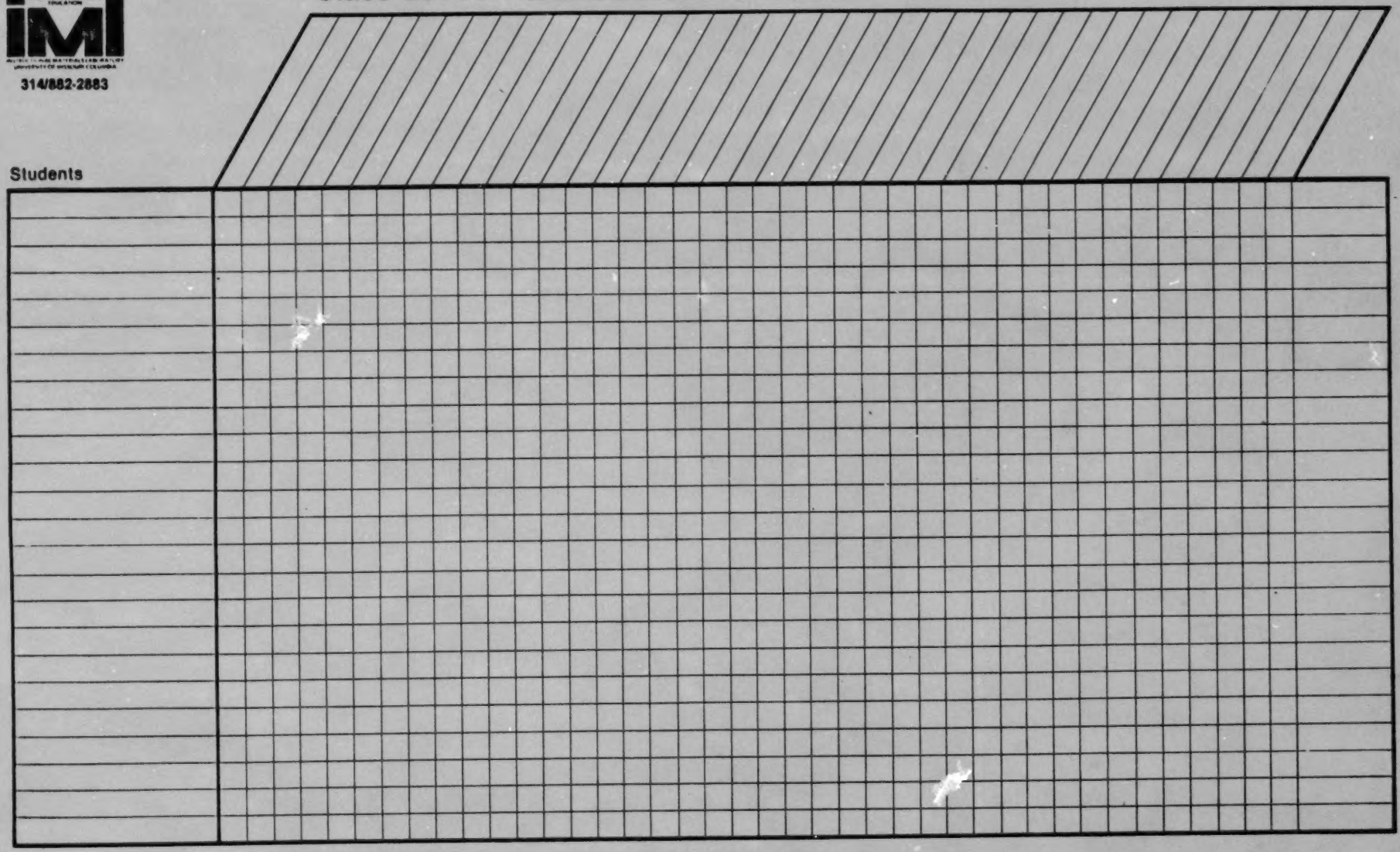
1. Arc Welding
2. Oxy-Acetylene Welding
3. Power Tools
4. Painting
5. Tool Sharpening
6. Cold Metal Work
7. Project Construction

TIME ALLOTMENT FOR AGRICULTURAL MECHANICS SKILLS IN ANIMAL SCIENCE AND PLANT SCIENCE

	Animal Science		Plant Science	
	Class	Shop	Class	Shop
Hand and portable power woodworking tools	8	10	-	-
Power tools (all)	1	1	1	5
Arc welding	3	10	2	7
Cold metal	-	-	2	6
Painting	1	1	1	1
Tool sharpening	1	2	1	3
Oxy-acetylene cutting	1	3	-	-
Oxy-acetylene welding	-	-	1	6
Materials selection, plan reading, and interpretation	-	-	3	-
Projects	-	2	-	21
Total Periods	**15**	**30**	**11**	**49**

314/882-2883

Class Section _____



UNIT - ARC WELDING

Lesson 1: What safety practices should I follow when arc welding?

Objective: At the end of this lesson, the student will be able to follow basic safety practices while arc welding.

Study Questions:

1. **What types of hazards exist for the operator and others during the arc welding process?**
2. **What should I do to avoid electrical shock when arc welding?**
3. **How can I avoid burns while arc welding?**
4. **What can I do to avoid harmful light rays which result from arc welding?**
5. **How do I limit the hazards caused by harmful fumes when I weld?**
6. **What safety practices should I follow when arc welding to limit the danger of fire?**

References:

1. Power Tool Safety and Operation, Hoerner and Bettis, pp. 89-92.
2. Arc Welding Lessons, Kugler, Class Lesson No. 7.
3. Welding Skills and Practices, Giachino, Weeks, and Brune, Chapter 3.
4. Modern Agriculture Mechanics, Wakeman, Chapter 7.
5. Shopwork on the Farm, 2nd ed., Jones, Chapter 16.

UNIT - ARC WELDING

Lesson 1: What safety practices should I follow when arc welding?

TEACHING PROCEDURES

A. Review

B. Motivation: Ask the students if they have ever been burned or shocked from using the arc welder. Ask the students how those burns or shocks could have been avoided.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students what types of hazards can occur while arc welding.

   What types of hazards exist for the operator and others during the arc welding process?

   1) Electrical shock
   2) Burns
   3) Harmful light rays
   4) Harmful fumes
   5) Fire

2. Ask the students how they can avoid electrical shock when welding.

   What should I do to avoid electrical shock when arc welding?

   1) Do not lay the electrode holder on a grounded cable.
   2) Do not stand in water or on a wet floor while welding.
   3) Before repairing or adjusting the welder, make sure that the machine is off in two places - the on-off switch and the main switch.
   4) Check the welding cables for damaged insulation before welding.
   5) When welding outside, stand on a piece of nonconductive material, such as a dry piece of lumber.

3. Ask the students how they can avoid burns while arc welding.

   How can I avoid burns while arc welding?

   1) Use caution in releasing the ground clamp after welding. It may have heated during welding because of a poor connection.
   2) Do not leave hot metal where others might come in contact with it. If the metal cannot be moved, chalk the word "HOT" on it plainly in large letters.
   3) Handle hot metal with pliers or tongs - never with a gloved hand.

4. Ask the students what they can do to avoid harmful light rays which result from arc welding.

What can I do to avoid harmful light rays which result from arc welding?

1) Always wear a welding helmet with the proper shade of lens - number 10 or darker.
2) Wear long sleeves and gauntlet-style gloves.
3) Do not wear cuffs on pants.
4) Avoid wearing low-top shoes or tennis shoes in the shop.
5) Do not leave any skin exposed to rays from the welder.
6) Wear safety glasses at all times.
7) Shout the word "Cover!" to all people standing nearby when ready to strike the arc.
8) Never look at the arc with an unprotected eye.
9) Always check the helmet and lens for cracks before using.

5. Ask the students how they can limit the hazards of harmful fumes caused by welding.

How do I limit the hazards caused by harmful fumes when I weld?

1) Do not weld without proper ventilation.
2) Do not weld galvanized metal inside the shop.

6. Ask the students what safety practices to follow to limit the danger of fire.

What safety practices should I follow when arc welding to limit the danger of fire?

1) Work over concrete or fireproof surfaces.
2) Do not weld when wearing dirty or oil-soaked clothing.
3) Clear the work area of flammable materials before welding.
4) Use a dry chemical fire extinguisher, never water, to put out fires near the welder.

F. Other Activities

The teacher may wish to utilize the activity sheet on the Arc Welder from the Power Tool Safety and Operation Instructor Packet by HOBAR (also available from the Instructional Materials Laboratory) as a part of this lesson.

G. Summary

To arc weld safely, the student should:

1. Avoid electrical shock by carefully checking the equipment and the environment for hazards before welding.
2. Avoid burns by handling hot metal with the proper tools.
3. Avoid harmful light rays by wearing protective clothing, a helmet with the proper lens, and protective eyewear.
4. Limit the hazards of harmful fumes by only welding where there is proper ventilation.
5. Limit the danger of fire by clearing flammable materials from the work area.

H. Answers to Evaluation

(NOTE: The teacher may also want to administer the Arc Welder Safety Exam by HOBAR as an additional evaluation for this lesson. These exams are available in pad form from the Instructional Materials Laboratory.)

1. T
2. T
3. F
4. T
5. T
6. T
7. T
8. T
9. T
10. T

UNIT - ARC WELDING

Lesson 1: What safety practices should I follow when arc welding?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. Before repairing or adjusting the welder, the welder should be off in two places.

T F 2. Handle hot metal with pliers or tongs - never with a gloved hand.

T F 3. Tennis shoes would be appropriate footwear for welding in the shop.

T F 4. A welding helmet should always be checked for cracks before each use.

T F 5. Safety glasses should be worn at all times when arc welding.

T F 6. Never weld without proper ventilation.

T F 7. Before starting to weld, always check the welding cables for damaged insulation.

T F 8. The lens for arc welding should be number 10 or darker.

T F 9. Always warn others who may be in the area before striking the arc.

T F 10. Always clear flammable materials from the area before starting to weld.

UNIT - ARC WELDING

Lesson 2: How is distortion controlled?

Objective: At the end of the lesson, the student will be able to utilize methods of controlling expansion and contraction resulting from welding heat.

Study Questions:

1. **How do expansion and contraction affect a weld?**
2. **What welding techniques can be used to reduce distortion?**
3. **How can contraction forces be used to achieve the desired weld?**
4. **What mechanical means may be employed to reduce distortion?**

References:

1. Arc Welding Lessons, Kugler, Lesson 3.
2. Welding Skills and Practices, Giachino, Weeks, and Brune, Chapter 2.
3. Modern Agricultural Mechanics, Wakeman, Chapter 7.
4. Shopwork on the Farm, Jones, Chapter 16.
5. Transparency Masters
   a. TM-1: Distortion in Welding
   b. TM-2: Welding Techniques to Control Distortion
   c. TM-3: Using Contraction Forces to Advantage
   d. TM-4: Mechanical Means to Control Distortion

UNIT - ARC WELDING

Lesson 2: How is distortion controlled?

TEACHING PROCEDURES

A. Review

B. Motivation: Ask the student what effect the heat from welding has on the base metal. Ask the students if a 1/2-inch plate and a 1/8-inch plate would be affected the same by welding at a setting of 115 amps.

C. Assignment

D. Supervised Study

E. Discussion

1. Show TM-1 to the students. Ask the students how expansion and contraction forces affect a weld.

   How do expansion and contraction affect a weld?

   1) Heated metal expands.
   2) Cooling metal contracts.
   3) Distortion occurs when the natural expansion or contraction is restricted. (Refer to TM-1.)

2. Show TM-2 to the students. Ask the students what welding techniques can be used to reduce distortion.

   What welding techniques can be used to reduce distortion?

   1) Tack weld at regular intervals along the joint, at each end, and at stress points. (Refer to TM-2.)
   2) Use a back-step method of running a series of short beads rather than one long bead to reduce distortion. (Refer to TM-2.)
   3) Peen or strike the surrounding area with a ball-peen hammer. This helps to relieve internal stress and reduce distortion. (Refer to TM-2.)
   4) Preheat the base metal to cause uniform expansion and contraction. This reduces distortion. (Refer to TM-2.)
   5) Use as few passes as possible. (Refer to TM-2.)

3. Show TM-3 to the students. Ask the students how contraction forces can be used to advantage in welding.

   How can contraction forces be used to achieve the desired weld?

   1) By prepositioning and tacking the piece slightly out of position in the opposite direction from the contraction force, the piece will be pulled into alignment as the weld joint cools. (Refer to TM-3.)

2) Prebending the piece to be welded in the opposite direction from the contraction force allows for the piece to be unbent into correct alignment as the piece cools. (Refer to TM-3.)
3) Contraction forces can also be offset by other contraction forces when welding is done in the proper sequence, such as skip welding on alternate sides of the base metal. (Refer to TM-3.)

4. Ask the student what mechanical means can be used to reduce distortion. Show TM-4 to the students to illustrate.

What mechanical means may be employed to reduce distortion?

1) Clamps and jigs can be used to hold the base metal in a rigid position during welding. (Refer to TM-4.)

F. Other Activities

G. Summary

To control distortion a student should:

1. Use various welding techniques such as tack welding, back-step welding, preheating, peening, or using as few welding passes as possible.
2. Put the contraction forces to work by prepositioning, prebending, or alternate welding.
3. Use mechanical means such as clamps or jigs to limit distortion.

H. Answers to Evaluation

1. F
2. T
3. T
4. F
5. T
6. T
7. T
8. T

UNIT - ARC WELDING

Lesson 2: How is distortion controlled?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle F if the statement is false.

T F 1. As a bead cools, it expands and causes warpage.

T F 2. Peening as the weld cools reduces distortion.

T F 3. Increasing heat and increasing welding time increase distortion.

T F 4. Preheating causes uniform expansion and increased distortion.

T F 5. Contraction forces can be offset by estimating their effect and allowing for it before welding.

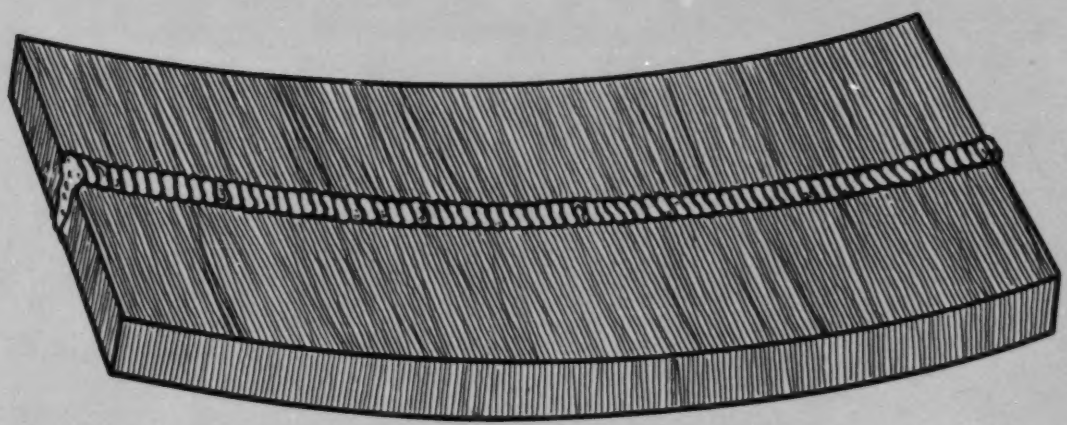
T F 6. Skip welding on alternate sides of a patch on thin material will reduce problems with distortion.

T F 7. Prebending pieces to be welded is one method of allowing contraction forces to work to the welder's advantage.

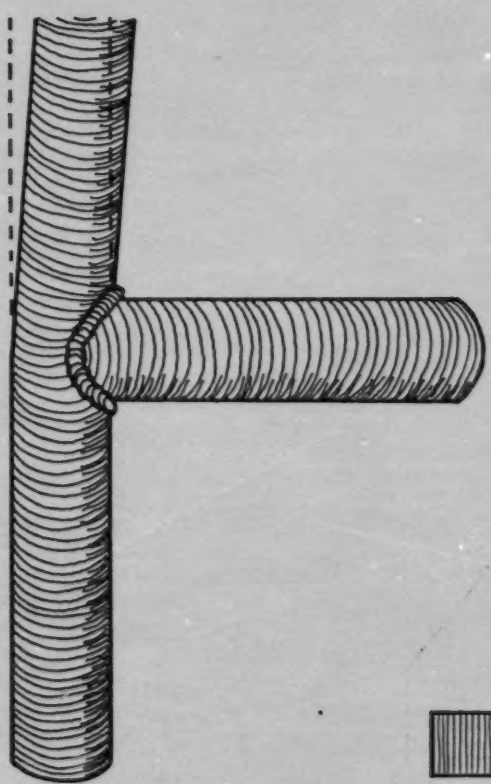
T F 8. Tack welding is a common method of controlling distortion.

TM-1

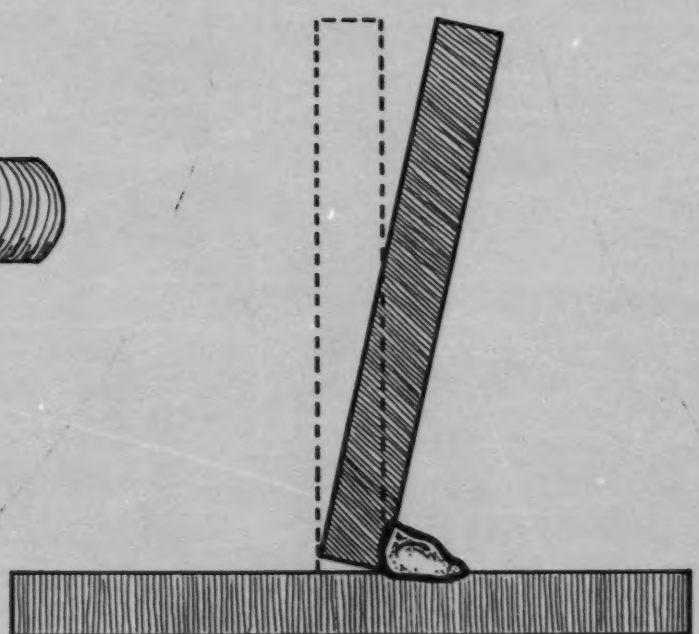
Distortion in Welding



Butt Weld



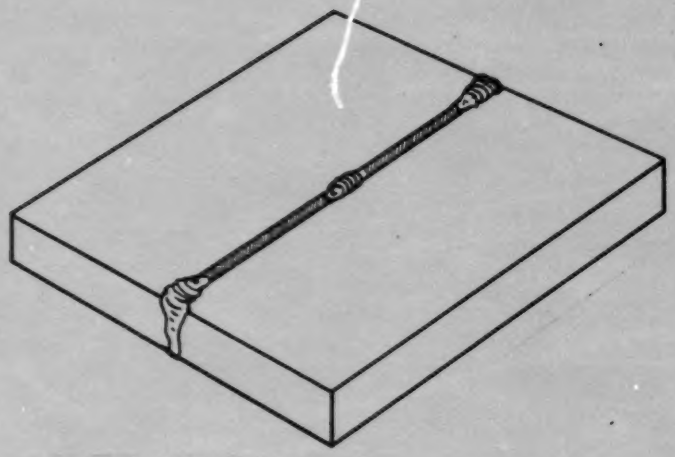
Pipe Weld



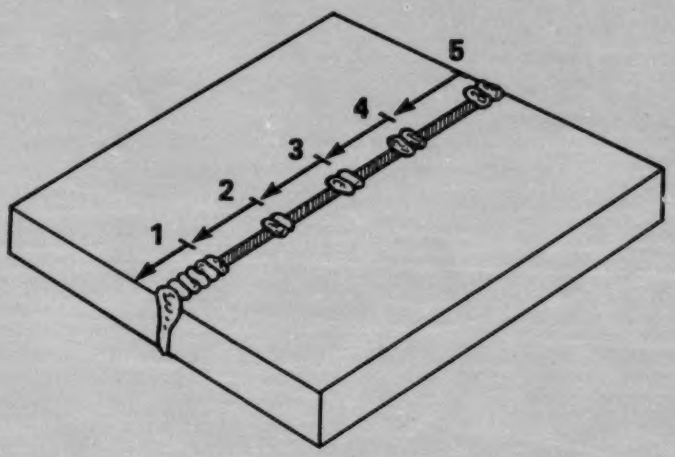
Fillet Weld

Welding Techniques to Control Distortion

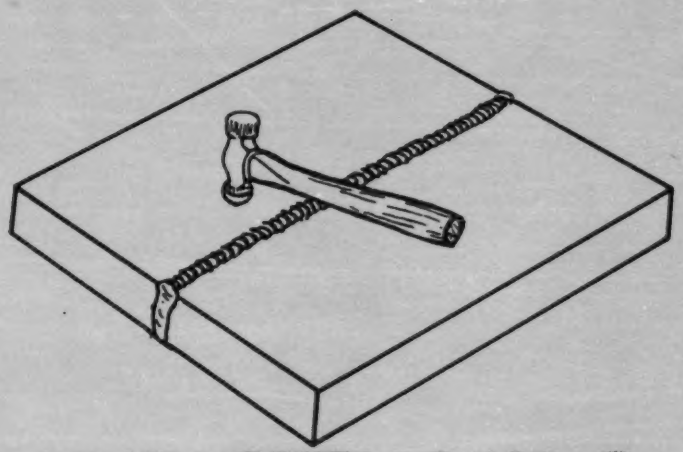
TM-2



Tack Welding



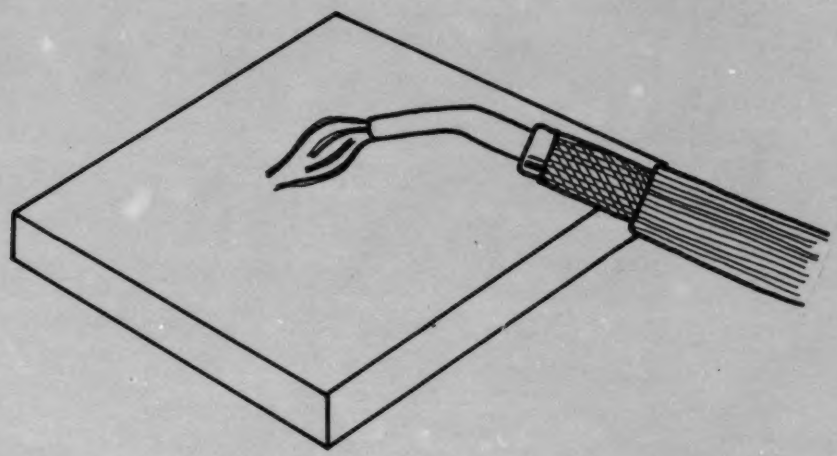
Back-step Welding



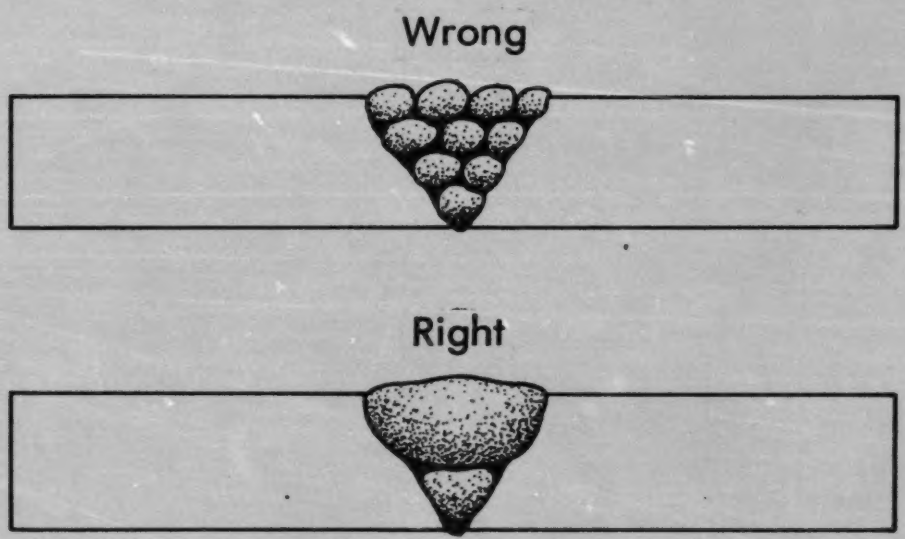
Peening the Surrounding Area

Welding Techniques to Control Distortion

TM-2 (cont.)

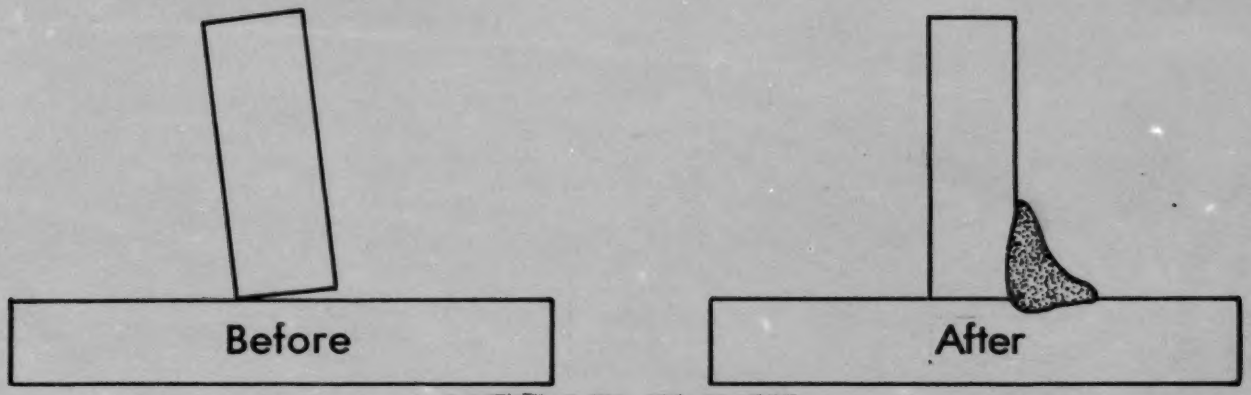


Preheating the Base Metal

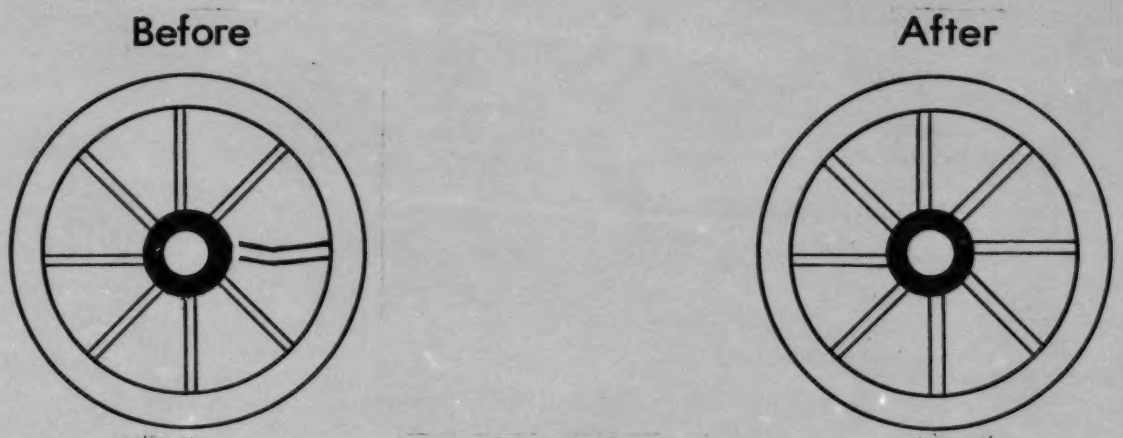


Use Fewer Passes

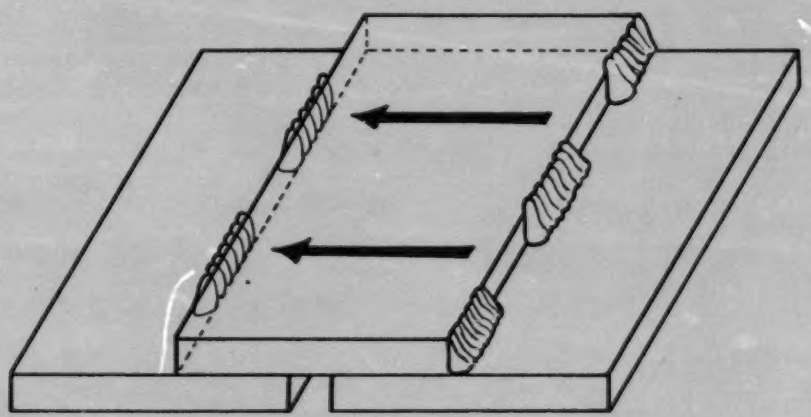
Using Contraction Forces to Advantage



Prepositioning

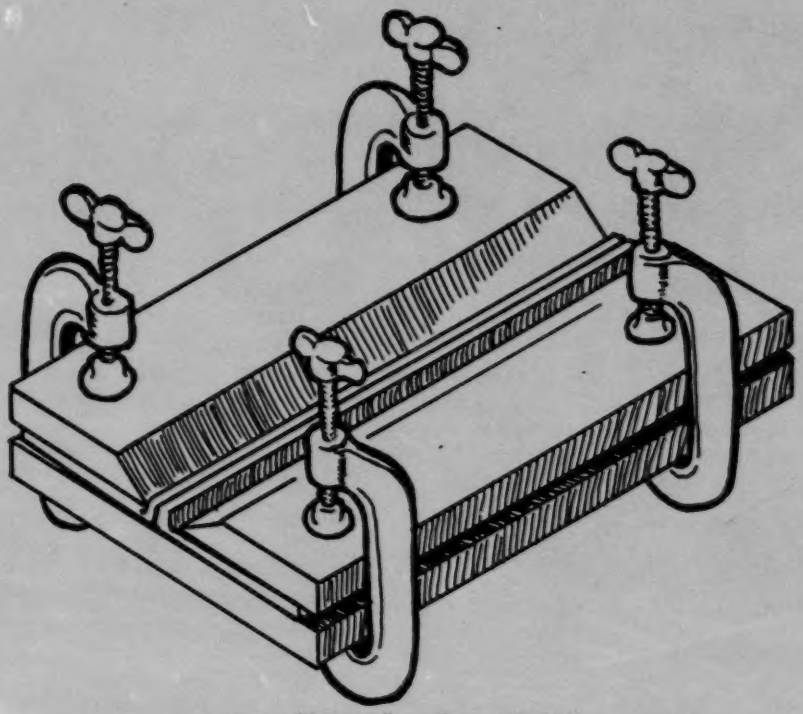


Prebending

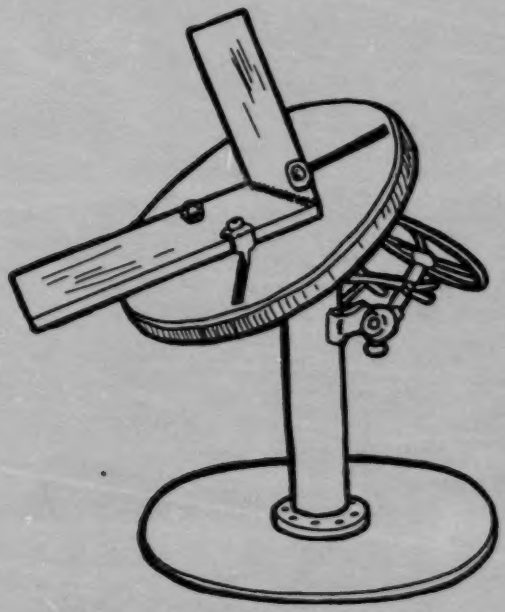


Alternate Welding

Mechanical Means to Control Distortion



Using Clamps



Using Jigs

UNIT - ARC WELDING

Lesson 3: How do I select and care for electrodes?

Objective: Upon conclusion of the lesson, students will be able to identify and care for the different types of electric welding electrodes.

Study Questions:

1. **What factors are involved in selecting electrodes?**
2. **What systems are used to identify electrodes?**
3. **What do the different characters mean in the AWS electrode classification system?**
4. **What are some commonly used electrodes?**
5. **How should I care for electrodes?**

References:

1. Arc Welding Lessons, Kugler, Lesson 4.
2. Welding Skills and Practices, Giachino, Weeks, and Brune, Chapter 4.
3. Modern Agricultural Mechanics, Wakeman, Chapter 7.
4. Shopwork on the Farm, Jones, Chapter 16.
5. Transparency Master
   a. TM-5: Electrode Color Markings
6. Handouts
   a. HO-1: AWS Numbering System
   b. HO-2: Electrode Classification Chart (E60 Series)
   c. HO-3: Electrode Classification Chart (E70 Series)

UNIT - ARC WELDING

Lesson 3: How do I select and care for electrodes?

TEACHING PROCEDURES

A. Review

B. Motivation: Pass examples of several different types and sizes of electrodes around the class. Ask the students why different sizes and types of electrodes are necessary. Ask the students how base metal type and thickness influence electrode selection.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students what factors affect the selection of electrodes.

   What factors are involved in selecting electrodes?

   1) Kinds of metal to be welded.
   2) Required tensile strength and ductility of the weld.
   3) Suitability for alternating or direct current (and polarity in the case of direct current).
   4) Type of joint.
   5) Position in which the weld is to be made.
   6) Coating or flux type.
   7) Size or diameter of rods required.

2. Ask the students what systems are used to identify electrodes. Show TM-5 to the students. Hand examples of color-coded electrodes around the classroom. Identify the electrodes for the students.

   What systems are used to identify electrodes?

   1) National Electrical Manufacturers Association (NEMA) color code system. Uses primary, secondary and group color markings to identify electrodes. (Refer to TM-5.)
   2) American Welding Society (AWS) numbering system - more widely used for agricultural purposes.

3. Hand out HO-1 to the students. Ask the students what each character in the AWS numbering system means. Hand out HO-2 and HO-3 to the students. Discuss how the numbering system carries through in these common series of electrodes.

What do the different characters mean in the AWS electrode classification system?

1) Letter "E" - designates that electrode is of the metal arc type. (Refer to HO-1.)
2) First and second digits - refer to the minimum allowable tensile strength of the deposited weld metal in thousands of pounds per square inch. (Refer to HO-1.)
3) Third digit - refers to position of weld. (Refer to HO-1.)
   a) 1 - suitable for use in flat, horizontal, vertical, and overhead positions.
   b) 2 - suitable for flat and vertical positions.
   c) 3 - suitable for flat positions.
4) Fourth digit - shows some special characteristic of the electrode such as weld quality, type of arc, and amount of penetration. (Refer to HO-1.)
   a) 0 - direct current, reverse polarity (DCRP), produces high quality deposits with deep penetration and flat to slightly concave beads.
   b) 1 - alternating current (AC) or DCRP, produces high quality deposits with deep penetration and flat to slightly concave beads.
   c) 2 - AC or direct current, straight polarity (DCSP), produces medium quality deposits, medium arc, medium penetration, and convex beads.
   d) 3 - AC or DCSP, produces medium quality deposits, soft arc, shallow penetration and slightly convex beads.
   e) 4 - AC or DC, either polarity, produces fast deposition rate, deep groove butt, fillet and lap welds, medium penetration, easy slag removal.
   f) 5 - DCRP, produces high quality deposits, soft arc, moderate penetration, flat to slightly convex bead, low hydrogen in weld deposits.
   g) 6 - AC or DCRP, produces qualities similar to a 5 (DCRP).
   h) 7 - AC or DCSP for horizontal fillet welds of AC or DC, either polarity for flat welds.
   i) 8 - AC or DCRP.
5) Suffixes - indicate specific additions of alloying elements to the electrode.
6) Example series of electrodes. (Refer to HO-2 and HO-3.)

4. Ask the students which electrodes are commonly used.

What are some commonly used electrodes?

1) E6011 - for welding mild steel; deep penetration
2) E6013 - for welding mild steel; medium penetration
3) E7018 (low hydrogen rod) - for welding higher carbon steel
4) ENi - for welding cast iron; machinable after welding
5) ESt - for welding cast iron; not machinable

5. Ask the students how to care for electrodes.

How should I care for electrodes?

1) All electrodes must be kept in a dry place.
2) Low hydrogen electrodes (E7018) must be stored at 300° F. or they lose the low hydrogen characteristics.
3) Avoid dropping or bumping electrodes or electrode containers (which may crack or break the flux coating).
4) Only take as many electrodes to the shop as will be needed for the job (especially if electrodes are stored in an electrode oven).

F. Other Activities

G. Summary

When selecting and caring for electrodes, a student should:

1. Consider a wide variety of factors to choose the proper electrode.
2. Become familiar with both the AWS and NEMA systems of classification, so that the proper electrode can be selected.
3. Keep electrodes dry.

H. Answers to Evaluation

1. Any five of the following:
   a. kinds of metal to be welded
   b. required tensile strength and ductility of the weld
   c. suitability for alternating or direct current and polarity in case of direct current
   d. type of joint
   e. position in which weld is to be made
   f. coating or flux needed
   g. size or diameter of rod needed
2. a. electric arc
   b. 60,000 psi
   c. any position
   d. type of current, type of flux, penetration of arc, special applications
3. F
4. T
5. T

UNIT - ARC WELDING

Lesson 3: How do I select and care for electrodes?

EVALUATION

1. Name five factors that are involved in selecting electrodes.

   a.

   b.

   c.

   d.

   e.

2. Answer the following questions concerning an E6013 electrode.

   a. What does the letter "E" stand for?

   b. What is the indicated tensile strength of the weld metal?

   c. In what position can this electrode be used?

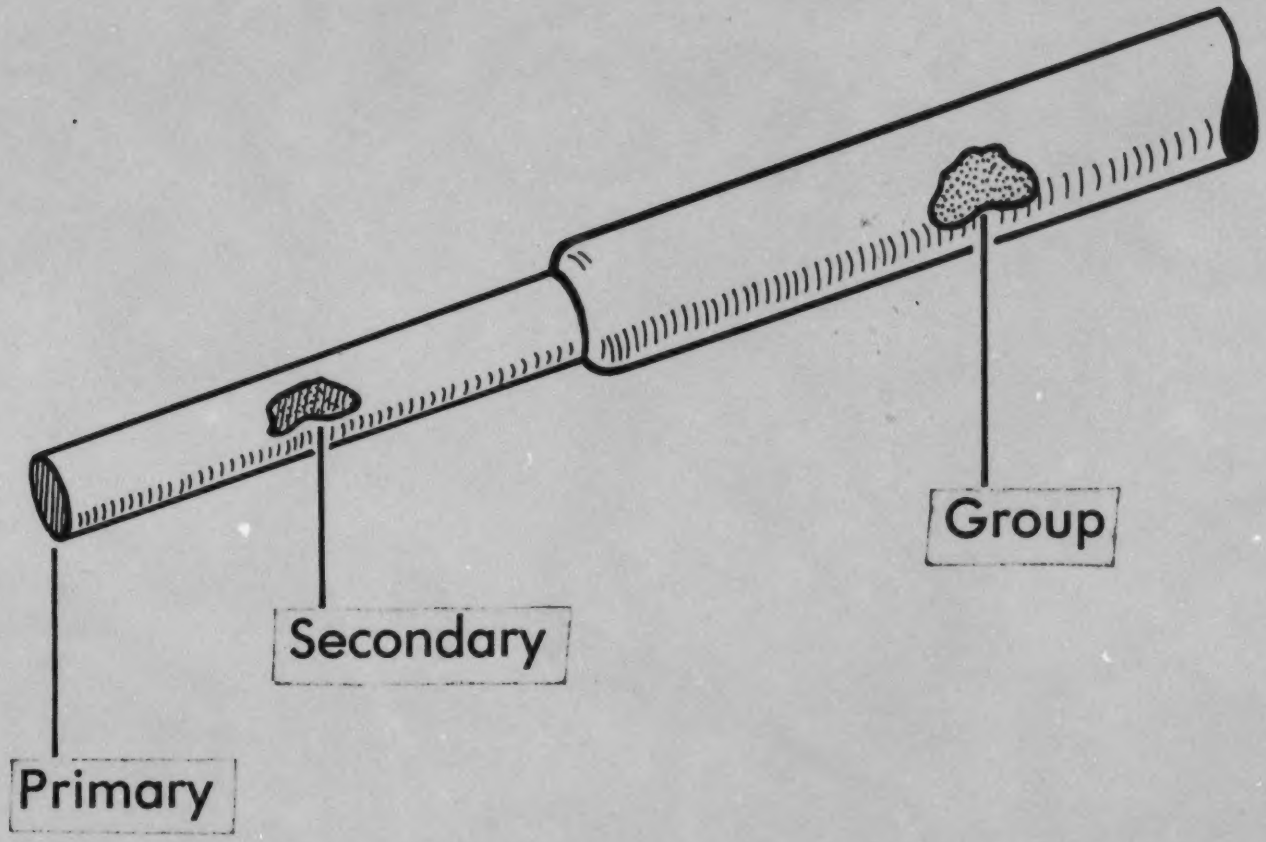
   d. What might be determined from the fourth number in an AWS code system?

T F 3. Electrodes are always identified by color markings on the end and side.

T F 4. Open containers of low hydrogen electrodes should always be kept in an electrode oven.

T F 5. Electrodes should be kept in a dry place.

Electrode Color Markings



AWS NUMBERING SYSTEM

Prefix "E" stands for electrode - designates arc welding.

In mild and low alloy steel electrodes:

First two digits of four digit numbers and first three digits of five digit numbers indicate tensile strength.

E60xx - 60,000 psi Tensile Strength
E70xx - 70,000 psi Tensile Strength
E80xx - 80,000 psi Tensile Strength
E90xx - 90,000 psi Tensile Strength
E100xx - 100,000 psi Tensile Strength
E110xx - 110,000 psi Tensile Strength

Next-to-last digit indicates position:

Exx1x - Indicates all positions
Exx2x - Indicates H-fillet or flat
Exx3x - Indicates flat position only

The last two digits together indicate the current to be used and the type of coating:

Exx10 - Organic - DC+ only
Exx11 - Organic - AC or DC+
Exx12 - Rutile - DC- or AC
Exx13 - Rutile - AC or DC-
Exx14 - Rutile, Iron Powder (approximately 30%) - AC or DC±
Exx16 - Low Hydrogen - DC+ or AC
Exx18 - Low Hydrogen, Iron Powder (approximately 25%) - DC+ or AC
Exx20 - High Iron Oxide - DC+ or AC
Exx24 - Rutile, Iron Powder (approximately 50%) - AC or DC±
Exx27 - Mineral, Iron Powder (approximately 50%) - AC or DC±

The suffix indicates a specific alloy in the deposit.
For example:

Exxxx-A1 -.50 Molybdenum
Exxxx-G* -.2 minimum Molybdenum, .3 minimum Chromium 1.0 minimum Manganese, .1 Vanadium

* Contains the minimum content of only one of these elements.

ELECTRODE CLASSIFICATION CHART
E60 Series

AWS classification number	Type of coating or covering	Capable of producing satisfactory welds in positions shown	Type of current
E6010	High-cellulose sodium	F, V, OH, H	For use with DC reverse polarity (electrode positive only).
E6011	High-cellulose potassium	F, V, OH, H	For use with AC or DC reverse polarity (electrode positive).
E6012	High titania sodium	F, V, OH, H	For use with DC straight polarity (electrode negative) or AC.
E6013	High-titania potassium	F, V, OH, H	For use with AC or DC straight polarity (electrode negative).
E6015	Low-hydrogen sodium	F, V, OH, H	For use with DC reverse polarity (electrode positive) only.
E6016	Low-hydrogen potassium	F, V, OH, H	For use with AC or DC reverse polarity (electrode positive).
E6020	High iron oxide	H-fillets, F	For use with DC straight polarity (electrode negative) or AC for horizontal fillet welds; and DC, either DC or AC for flat position welding.
E6024	Iron powder, titania	H-fillets F	For use with DC, either polarity, or AC.
E6027	Iron powder, iron oxide	H-fillets, F	For use with DC straight polarity (electrode negative) or AC for horizontal fillet welds; and DC, either polarity, or AC for flat position welding.
E6030	High iron oxide	F	For use with DC, either polarity, or AC.

F-Flat * H-Horizontal * V-Vertical * OH-Overhead

ELECTRODE CLASSIFICATION CHART

E70 Series

AWS classification number	Type of coating or covering	Capable of producing satisfactory welds in positions shown	Type of current
E7010	High-cellulose sodium	F, V, OH, H	For use with DC reverse polarity (electrode positive only).
E7011	High-cellulose potassium	F, V, OH, H	Use with AC or DC reverse polarity (electrode positive).
E7014	Iron powder	F, V, OH, H	For use DCRP and DCSP and AC.
E7015	Low-hydrogen sodium	F, V, OH, H	For use DC reverse polarity (electrode positive).
E7016	Low-hydrogen potassium	F, V, OH, H	For use DCRP and AC.
E7018	Low-hydrogen iron powder (20-40% iron powder)	F, V, OH, H	For use DCRP or AC.
E7020	Ferric oxide and quartz	Fillets, F	For use DCSP or AC.
E7024	Iron powder	Fillets F	For use DC either polarity and AC.
E7027	Iron powder	Fillets Flats	For use DCSP or AC. For use DCRP or AC.
E7028	Iron powder (low-hydrogen)	Fillets Flats	For use with DCRP or AC. For use with DCRP.

F-Flat * H-Horizontal * V-Vertical * OH-Overhead

UNIT - ARC WELDING

Lesson 4: How can I identify the metal to be welded?

Objective: At the end of this lesson, the student will be able to identify metals being welded.

Study Questions:

1. **Why is it important to identify metal to be welded?**
2. **What are some commonly used tests which identify metals?**
3. **What are the characteristics of some common metals?**

References:

1. Arc Welding Lessons, Kugler, Lesson 6.
2. Welding Skills and Practices, Giachino, Weeks, and Brune, Chapter 2.
3. Modern Agricultural Mechanics, Wakeman, Chapter 4.
4. Handout
   a. HO-4: Characteristics of Some Common Metals
5. Shop Demonstration
   a. #1: Identify Metal Using the Spark Test

UNIT - ARC WELDING

Lesson 4: How can I identify the metal to be welded?

TEACHING PROCEDURES

A. Review

B. Motivation: Pass examples of various types of metal around the classroom. Include low carbon steels (flat metal, angle iron), high carbon steels (small gas engine valve), cast iron, etc. Ask the students if all of the types of metal have similar characteristics. Ask the students if all of the types can be welded successfully with the same electrodes.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students why it is important to identify metal to be welded.

Why is it important to identify metal to be welded?

1) Being able to weld any metal successfully is dependent on identifying the metal, then using the correct electrode and procedures to weld.

2. Ask the students to describe some of the commonly used tests to identify metals. List each method on the board.

What are some commonly used tests which identify metals?

1) Magnetic test - separates iron and steel from the nonferrous metals.
   a) All iron and steel (except high grade stainless steel) will be affected by magnetism.

2) Heat test - identifies the metal's ability to be welded.
   a) Ferrous metals will turn red when heated.
   b) The test consists of melting a puddle in the metal, using an oxy-acetylene torch with a neutral flame.
   c) The puddle should not spark excessively and it should be fluid.
   d) The puddle should not boil.
   e) If the metal that was melted has an even, shiny surface after it solidifies, the metal will generally have good welding properties.

3) Spark test - uses a grinder as the test equipment.
   a) Different metals throw off different sparks when they come in contact with the grinding wheel.
   b) The sparks differ in:
      (1) The color of the sparks.
      (2) The length of the sparks.
      (3) The number of explosions along the length of the individual sparks.
   c) When performing a spark test, use as light a contact as possible against the grinding wheel.
   d) The sparks are easier to see if a black background is used.
   e) Alloys of iron and steel cause the sparks to branch off at right angles and cause the sparks to be different colors.
   f) As the carbon content of the steel increases, the color of the spark becomes brighter.

3. Hand out HO-4 to the students. Ask the students to identify the characteristics of some common metals.

What are the characteristics of some common metals?

1) Ferrous metals - metals whose chief ingredient is iron. (Refer to HO-4.)
   a) Low carbon steel - dark gray in color; strongly magnetic; melts fast, becoming bright red before melting; has a melting point of 2700° F.; used for general applications where high strength is not needed.
   b) Medium carbon steels - dark gray in color; strongly magnetic; melts fast, becoming bright red before melting; has a melting point of 2600° F; used where more strength is needed than low carbon steel can provide.
   c) High carbon steels - dark gray in color; strongly magnetic; melts fast, becoming bright red before melting; has a melting point of 2500° F; used where the ability to hold a sharp edge is important.
   d) Cast iron - dull gray in color; strongly magnetic; melts slowly, becoming a dull red before melting; has a melting point of 2300° F.; used where the weight and lack of flexibility are not a liability.
   e) Stainless steel - bright, silvery, smooth appearance; slightly magnetic (high quality stainless steel is not magnetic); melts fast, becoming bright red before melting; has a melting point of 2500°-2800° F. (depending on the alloying metals used); used where resistance to corrosion and/or the ability to be sterilized is important.
2) Nonferrous metals - metals that do not contain iron.
   a) Aluminum - silver-white in color; nonmagnetic; melts fast; has a melting point of 1215° F. for pure aluminum, 3660° F for aluminum oxide; used where light weight is needed.

   b) Bronze - opaque yellow in color; nonmagnetic; melts fast; has a melting point of 1562°-1832° F. (for a mixture of 90% copper and 10% tin); used for electrical connections because of its high conductivity of electrical current.

c) Brass - reddish to yellowish, depending on the percentage of zinc in the brass; nonmagnetic; melts fast; has a melting point of 1868°-1886° F. (for a typical red brass) or 1652°-1724° F. (for a typical yellow brass); used where water would rust through steel.

F. Other Activities

Shop Demonstration
#1 - Identifying Metal Using the Spark Test

G. Summary

When identifying metal to be welded, the student should:

1. Use tests such as the magnetic test, the heat test, and the spark test to identify the metal.
2. Use this identification to select the correct electrode and procedures to weld the metal.

H. Answers to Evaluation

1. F
2. T
3. T
4. T

UNIT - ARC WELDING

Lesson 4: How can I identify the metal to be welded?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. All nonferrous metals are magnetic.

T F 2. Sparks from a high carbon steel should be brighter than sparks from a low carbon steel.

T F 3. When a metal turns red when heated, this indicates the presence of iron.

T F 4. The spark test uses differences in the color of sparks, length of sparks, and the number and shape of explosions along the sparks to identify various metals.

Characteristics of Some Common Metals

Metal	Surface Appearance	Magnetic Test	Heat Test	Melting Point, °F.	Uses
Ferrous Metals:					
Low carbon steel	Dark gray	Strongly magnetic	Melts fast; becomes bright red before melting.	2700	Implement frames, tanks, brackets, hoods, shop projects
Medium carbon steel	Dark gray	Strongly magnetic	Melts fast; becomes bright red before melting.	2600	Crankshafts, axles, connecting rods, high strength bolts
High carbon steel	Dark gray	Strongly magnetic	Melts fast; becomes bright red before melting.	2500	Plow shares, rake teeth, disk blades, mower knife sections, knotter disk holders
Cast iron	Dull gray	Strongly magnetic	Melts slowly; becomes dull red before melting.	2300	Engine blocks, differential housings, bearing supports,machinery housings
Stainless steel	Bright silver, smooth	Slightly; high quality is nonmagnetic.	Melts fast; becomes bright red before melting.	2500-2800	Dairy bulk tanks, food preparation equipment, chemical handling equipment
Nonferrous Metals					
Aluminum	Silver-white	None	Melts fast	1215 Aluminum (Al) 3660 Aluminum Oxide (Al_2O_3)	Storm doors and windows
Bronze	Opaque yellow	None	Melts fast	1562-1832 [90% Copper (Cu) and 10% Tin (Sn)]	Electrical contacts, electrical plugs, fuse connections
Brass	Reddish (5-20% Zinc) Yellowish (20-36% Zinc)	None	Melts fast	1868-1886 [90% Copper (Cu) and 10% Zinc (Zn)] 1652-1724 [70% Copper (Cu) and 30% Zinc (Zn)]	Radiator cores, fittings, plumbing parts

Adapted from **Metallurgy**, 5th Edition, by Johnson and Weeks; **Modern Agricultural Mechanics**, by Wakeman; and **Modern Welding**, by Althouse, Turnquist and Bowditch.

UNIT - ARC WELDING

SHOP DEMONSTRATION #1: Identifying Metal Using the Spark Test

Objective: At the end of this demonstration, the student will be able to identify common metals using the spark test.

Tools Needed:

1. Bench grinder (preferably with a dark background)
2. Safety goggles
3. Vise grips

Materials Needed:

* 1. One each - large nail (16d or larger)
2. One each - high strength bolt
3. One each - worn out file
4. One each - cast iron radiator
5. One each - piece of black pipe
6. One each - stainless steel knife

Procedure:

Step 1: Demonstrate the spark test for low carbon steel using the large nail. (The following steps are applicable to each spark test.)

a) Lightly touch the metal to the grinding wheel.
b) To insure consistent results the same amount of pressure should be applied to the grinding wheel for each test.
c) During each test the following differences should be noted:
   1) Color of sparks
   2) Length of sparks
   3) Number of explosions along the length of individual sparks

Step 2: Demonstrate the spark test for medium carbon steel using the high strength bolt.

Step 3: Demonstrate the spark test for high carbon steel using the worn out file.

Step 4: Demonstrate the spark test for cast iron using the radiator.

Step 5: Demonstrate the spark test for wrought iron using the black pipe.

Step 6: Demonstrate the spark test for stainless steel using the knife.

* These items are suggestions only. Other examples of these metals found in the shop may be substituted.

UNIT - ARC WELDING

Lesson 5: What must I consider when welding in the horizontal and vertical positions?

Objective: At the end of this lesson, the student will be able to weld in the horizontal and vertical positions.

Study Questions:

1. **What are the different kinds of welds used in arc welding?**
2. **What are the types of joints commonly used in arc welding?**
3. **What are the different positions used in arc welding?**
4. **What must I do to obtain satisfactory welds when arc welding in the horizontal and vertical positions?**

References:

1. Arc Welding Lessons, Kugler, Lesson 8, Welding Operation Nos. 4, 5, and 6.
2. Welding Skills and Practices, Giachino, Weeks, and Brune, Chapters 3, 7, 8, 9 and 10.
3. Modern Agricultural Mechanics, Wakeman, Chapter 7.
4. Shopwork on the Farm, Jones, Chapter 16.
5. Transparency Masters
   a. TM-6: Kinds of Welds
   b. TM-7: Types of Joints
   c. TM-8: Welding Positions
   d. TM-9: Angles for Horizontal Welding
   e. TM-10: Angles for Vertical Welding
6. Shop Demonstrations
   a. #2: Butt Welding in the Horizontal Position
   b. #3: Vertical Down Fillet Welding
   c. #4: Vertical Up Fillet Welding
7. Shop Exercises
   a. #1: Butt Welding in the Horizontal Position
   b. #2: Vertical Down Fillet Welding
   c. #3: Vertical Up Fillet Welding

UNIT - ARC WELDING

Lesson 5: What must I consider when welding in the horizontal and vertical positions?

TEACHING PROCEDURES

A. Review of the previous lesson.

At the start of this lesson, review with the students points learned in Animal Science Agricultural Mechanics, especially:

1. Equipment used in arc welding.
2. Setting up the equipment and setting the amperage on the welder.
3. The importance of amperage setting, arc length, speed of travel, and lead angle in obtaining a satisfactory bead.
4. Shutting off and putting up the equipment when finished.

B. Motivation: Hand examples of various flat, horizontal, vertical, and overhead welds around to the class members. Ask the students what differences they see in each weld.

C. Assignment

D. Supervised Study

E. Discussion

1. Show TM-6 to the students. Ask the students what different kinds of welds are used in arc welding.

What are the different kinds of welds used in arc welding?

1) Fillet welds (Refer to TM-6.)
2) Groove welds
3) Bead welds

2. Show TM-7 to the students. Ask the students what types of joints are commonly used in arc welding.

What are the types of joints commonly used in arc welding?

1) Edge joints (Refer to TM-7.)
2) Tee joints
3) Butt joints
4) Corner joints
5) Lap joints

3. Show TM-8 to the students. Ask the students what positions are used in arc welding.

What are the different positions used in arc welding?

1) Horizontal (Refer to TM-8.)
2) Vertical
3) Overhead
4) Flat

4. Ask the students why changes in welding technique are necessary when welding in different positions. Ask the students what must be done differently to weld in each position. Show TM-9 to the students. Ask the students at what angles to hold the electrode in horizontal welding. Show TM-10 to the students. Ask the students at what angles to hold the electrode for vertical up and vertical down welding.

What must I do to obtain satisfactory welds when arc welding in the horizontal and vertical positions?

1) Changes in welding technique are necessary because gravity tries to pull the molten metal out of the crater. The changes in technique try to counteract this.
2) Horizontal position
   a) Hold shorter arc length than for flat position.
   b) Change lead angle to 20 degrees and work angles to 5 to 10 degrees. (Refer to TM-9.)
   c) If plates in a butt weld are thick enough to be beveled, only bevel the top piece.
3) Vertical position
   a) Welding in the vertical down position is usually restricted to light material to utilize the shallow penetration and keep from burning through.
   b) Change the work angle to 10 to 15 degrees for a vertical down weld to keep out in front of the slag. (Refer to TM-10.)
   c) Use little or no weaving on vertical down welds.
   d) For vertical up welds, start with the electrode at a work angle of 90 degrees to the work.
   e) Use a rocking technique to prevent drips and sags when gravity causes the puddle to run.

F. Other Activities

Shop Demonstrations
- #2: Butt Welding in the Horizontal Position
- #3: Vertical Down Fillet Welding
- #4: Vertical Up Fillet Welding

Shop Exercises
- #1: Butt Welding in the Horizontal Position
- #2: Vertical Down Fillet Welding
- #3: Vertical Up Fillet Welding

G. Summary

When welding in the horizontal and vertical positions, the student should:

1. Hold a shorter arc length than used for flat position welding.
2. Use the appropriate lead angle and work angle for each type of weld.
3. Bevel only the top plate for a horizontal weld.
4. Use little or no weaving on a vertical down weld.
5. Use a rocking technique to prevent drips and sags on vertical up welds.

H. Answers to Evaluation

1. F
2. T
3. F
4. T
5. T

UNIT - ARC WELDING

Lesson 5: What must I consider when welding in the horizontal and vertical positions?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. When preparing 1/4-inch plates for horizontal butt welding, you should bevel both plates.

T F 2. A rocking technique is used on vertical up welding to prevent drips and sags.

T F 3. Proper welding technique for horizontal welding would include holding the arc length longer than would be used for a similar weld in the flat position.

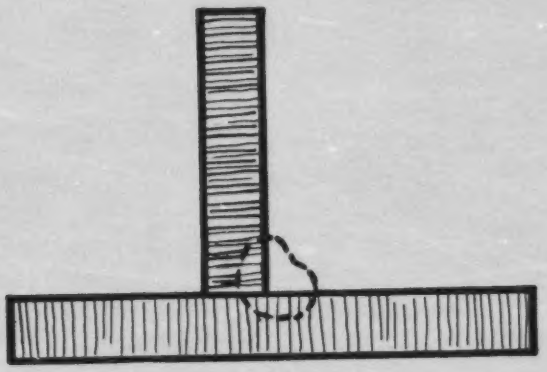
T F 4. Welding in the vertical down position is usually used for light material because of the shallow penetration obtained with this method.

T F 5. A vertical down weld should be made using little or no weaving motion.

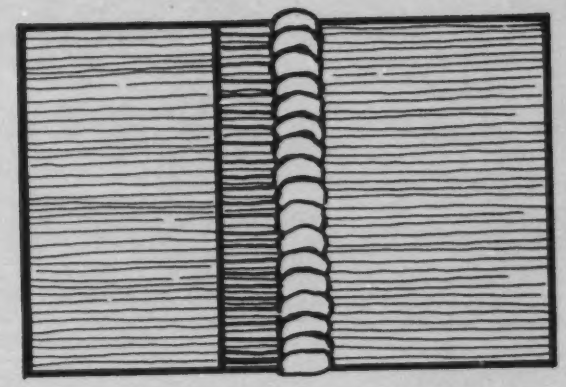
Kinds Of Welds

Fillet weld

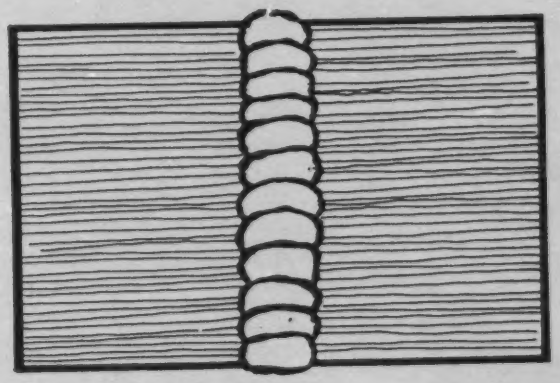
End view



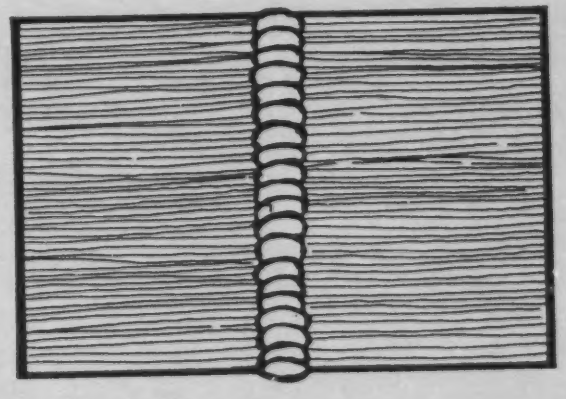
Top view



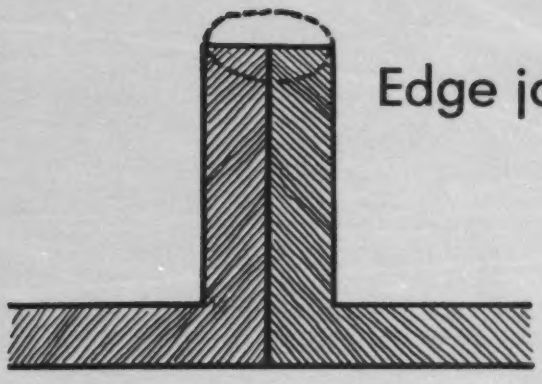
Groove weld



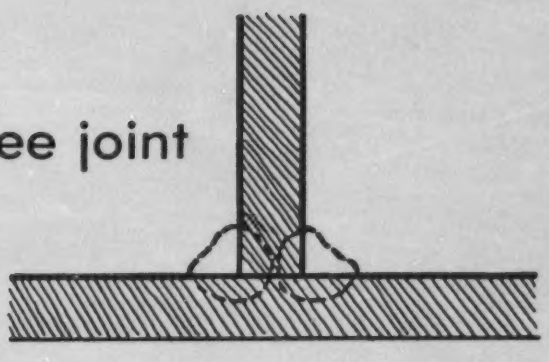
Bead weld



Types Of Joints

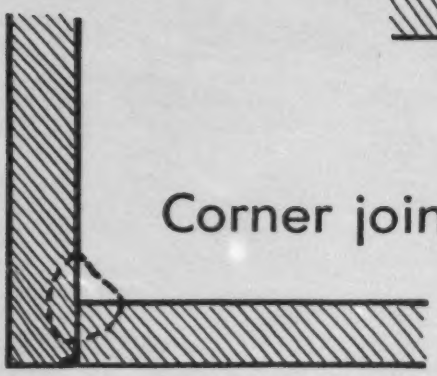


Edge joint



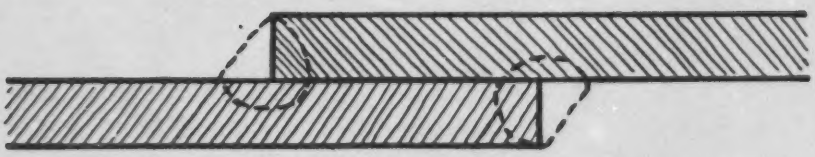
Tee joint

Butt joint

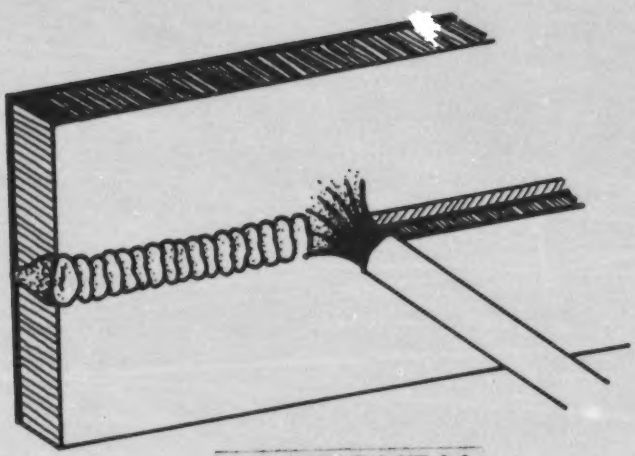


Corner joint

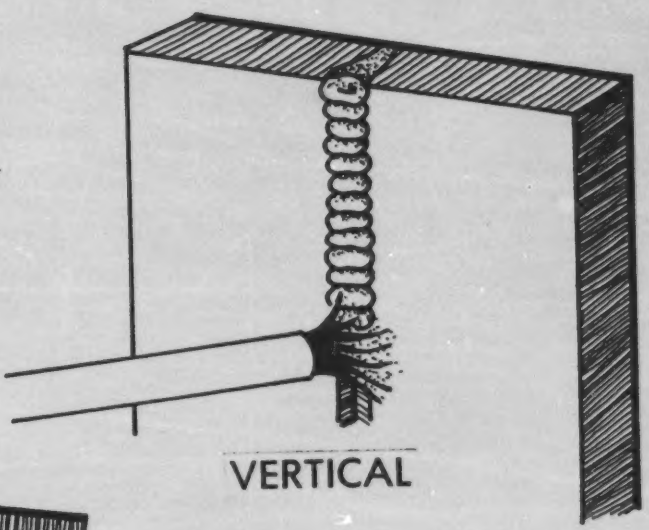
Lap joint



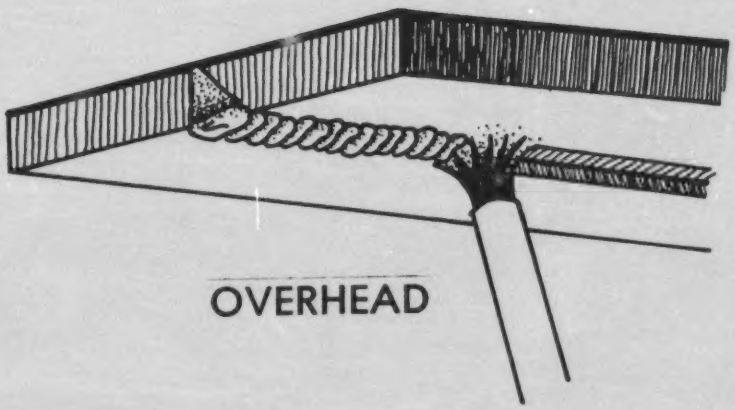
Welding Positions



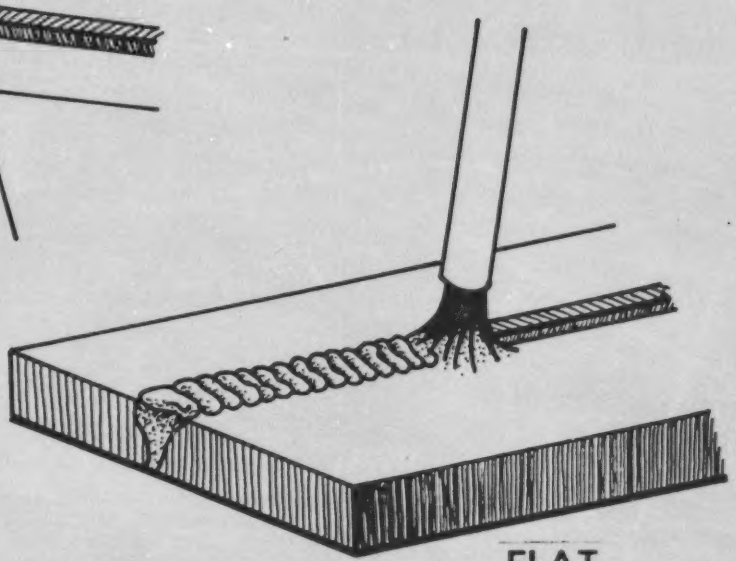
HORIZONTAL



VERTICAL



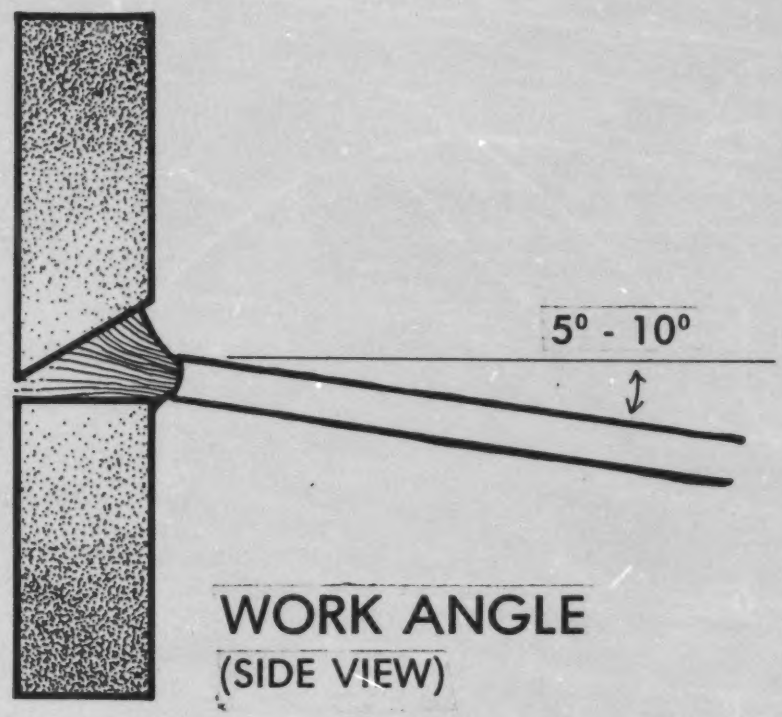
OVERHEAD



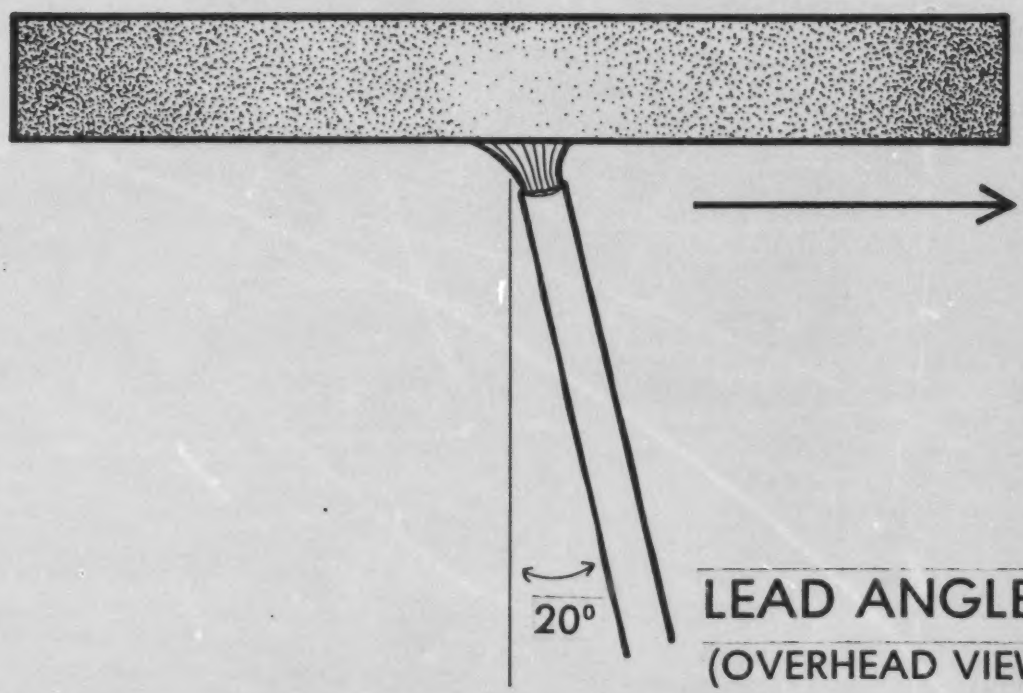
FLAT

TM-9

Angles for Horizontal Welding

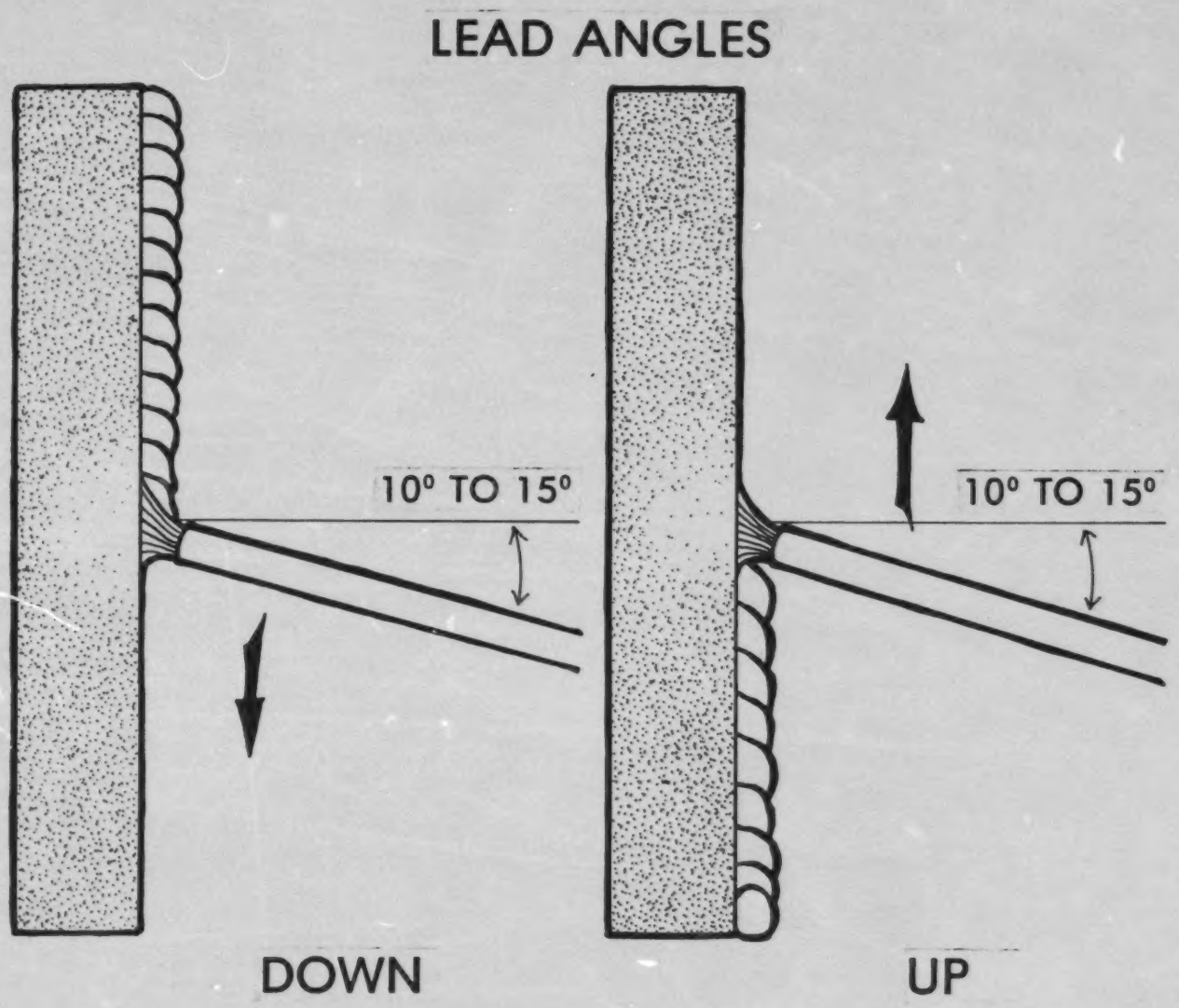


WORK ANGLE
(SIDE VIEW)



LEAD ANGLE
(OVERHEAD VIEW)

Angles for Vertical Welding



UNIT - ARC WELDING

SHOP DEMONSTRATION #2: Butt Welding in the Horizontal Position

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise of butt welding in the horizontal position.

Tools Needed:

1. AC arc welder
2. Helmet
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Chipping hammer

Materials Needed:

1. Two each - 3/8" x 4" x 8" hot rolled mild steel (HRMS) plate (Steel of different dimensions may be substituted.)
* 2. Four each - 1/8" x 14" AWS E6013 electrodes
3. Appropriate clothing

Procedure:

Step 1: (Optional) Demonstrate a review exercise in arc welding in the flat position for the students to complete prior to beginning horizontal welding. Suggested exercises include running 5 beads, butt welding, and/or fillet welding. (See the Agricultural Mechanics Unit for Animal Science, Demonstrations 2, 3, and 4 for these demonstrations.)

Step 2: Demonstrate proper metal preparation for welding using a wire brush. Bevel the edge of one plate at a 30-degree angle.

Step 3: Demonstrate tack welding the two pieces of metal together. Leave a 1/16-inch space between the pieces. Place a tack weld in the center of the joint, then tack the right end, where the weld will finish. Fasten the tacked pieces in the horizontal position. (The beveled piece should be on top.)

Step 4: Demonstrate how students will complete the required exercise in butt welding in the horizontal position.

a) Set the welder to a lower current position than would be used for butt welding the same pieces in the flat position.
b) Hold the electrode at a work angle of 5 to 10 degrees and a lead angle of 20 degrees in the direction of travel.
c) Begin welding, using a shorter arc length than would be used for a similar flat butt weld.
d) Use a slight weaving motion to dissipate heat as the weld progresses to completion.

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

Step 5: Demonstrate safe procedures in turning the welder off and laying the electrode holder aside.

Step 6: Demonstrate how to safely cool the weld, how to break it, and how to check the fusion and penetration. (Do not attempt to break a weld that is hotter then room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place the weld in the testing equipment with the weld facing up.
   2) When the welded joint breaks, examine the weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.

b) Destruction testing using vise and hammer/crescent wrench.
   1) Place the welded side away from you so that the force is applied against the stationary jaw of the vise.
   2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 7: Demonstrate reusing the pieces of metal for continued practice.

UNIT - ARC WELDING

SHOP EXERCISE #1: Butt Welding in the Horizontal Position

Objective: At the end of this exercise, the student should be able to butt weld in the horizontal position.

Tools Needed:

1. AC arc welder
2. Helmet
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Chipping hammer

Materials Needed:

1. Two each - 3/8" x 4" x 8" hot rolled mild steel (HRMS) plate (Steel of different dimensions may be substituted.)
* 2. Four each - 1/8" x 14" AWS E6013 electrodes
3. Appropriate clothing

Procedure:

Step 1: Before starting to practice horizontal welding, it may be helpful to practice welding in the flat position. Exercises which will be helpful would be running 5 beads, butt welding, and/or fillet welding. While practicing, observe carefully the arc length and speed of travel. (You may wish to review Exercises #2, #3, and #4 in the Agricultural Mechanics Unit for Animal Science.)

Step 2: Prepare the metal to be welded by using a wire brush to remove any rust, scale, etc. Bevel the edge of one plate at a 30-degree angle. (Refer to Figure 1.)

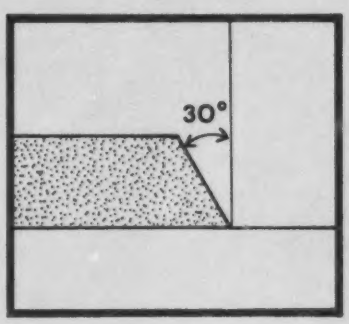


Figure 1

***Additional electrodes may be needed if steel of different dimensions is substituted.**

Step 3: Space the two pieces 1/16-inch apart. Tack weld the two pieces of metal together in the flat position. Place a tack weld in the center of the joint, then tack the right end, where the weld will finish. Fasten the tacked pieces in the horizontal position, with the beveled piece on top. (Refer to Figure 2.)

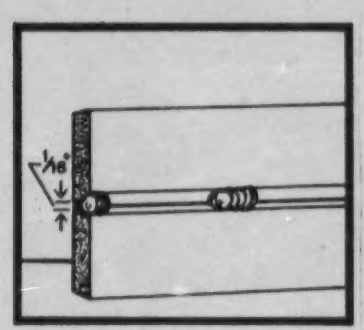


Figure 2

Step 4: Complete the required exercise in butt welding in the flat position.

a) Set the welder to a lower current position than would be used for butt welding the same pieces in the flat position.
b) Hold the electrode at a work angle of 5 to 10 degrees and a lead angle of 20 degrees in the direction of travel. (Refer to Figures 3 and 4.)
c) Begin welding using a shorter arc length than would be used for a similar flat butt weld.
d) Use a slight weaving motion to dissipate heat as the weld progresses to completion.

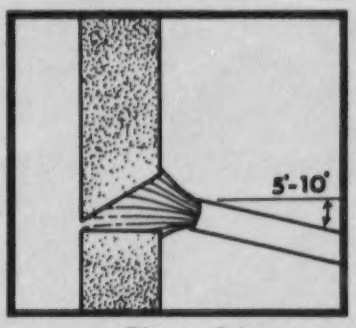


Figure 3

Step 5: Turn the welder off and lay the electrode holder aside.

Step 6: Cool the weld, break it, and check the weld for fusion and penetration. (Do not attempt to break a weld that is hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place the weld in the test equipment with the weld facing up.
   2) When the welded joint breaks, examine weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.
b) Destruction testing using vise and hammer/crescent wrench.
   1) Place the welded side away from you so that the force is applied against the stationary jaw.

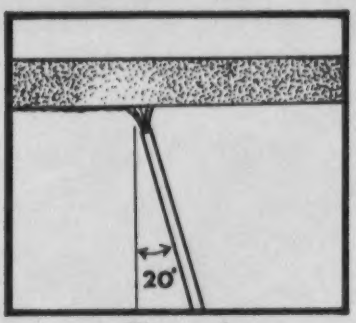


Figure 4

2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 7: Reuse the practice metal. You should be able to get four separate welds for each two pieces of practice metal. (When you have a weld with satisfactory surface appearance and penetration, allow the weld to air-cool for greater strength. Hand in to the instructor when requested.)

UNIT - ARC WELDING

SHOP DEMONSTRATION #3: Vertical Down Fillet Welding

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise of vertical down fillet welding.

Tools Needed:

1. AC arc welder
2. Helmet
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Chipping hammer

Materials Needed:

1. One each - 3/8" x 4" x 8" HRMS plate
2. One each - 3/8" x 1-1/2" x 8" HRMS plate (Steel of different dimensions may be substituted.)
* 3. Seven each - 1/8" x 14" AWS E6013 electrodes
4. Appropriate clothing

Procedure:

Step 1: Demonstrate proper metal preparation for welding using a wire brush.

Step 2: Demonstrate tack welding the two pieces of metal together. Place a tack weld in the center of the joint, then tack the right end, where the weld will finish. Then demonstrate fastening the tacked pieces in the vertical position.

Step 3: Demonstrate how students will complete the required exercise in vertical down welding.

a) Hold the electrode at a lead angle of 10 to 15 degrees. The work angle should be 45 degrees. (If metal of uneven thickness is being used, change the work angle to point more heat at the thicker piece.)
b) Starting at the top of the seam, strike the arc and deposit a bead in the root of the seam. Move straight down using no weaving motion.

Step 4: Demonstrate safe procedures in turning the welder off and laying the electrode holder aside.

*** Additional electrodes may be needed if steel of different dimensions is substituted.**

Step 5: Demonstrate how to safely cool the weld, how to break it, and how to check the fusion and penetration. (Do not attempt to break a weld that is hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place the weld in the testing equipment so that the result is to flatten the "V."
   2) When the welded joint breaks, examine the weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.

b) Destruction testing using vise.
   1) Place the weld in the vise so that as the vise is tightened it flattens the "V", breaking the weld.
   2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 6: Demonstrate reusing the pieces of metal for continued practice.

UNIT - ARC WELDING

SHOP EXERCISE #2: Vertical Down Fillet Welding

Objective: At the end of this exercise, the student should be able to weld a vertical down fillet weld on light material.

Tools Needed:

1. AC arc welder
2. Helmet
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Chipping hammer

Materials Needed:

1. One each - 3/8" x 4" x 8" HRMS plate
2. One each - 3/8" x 1-1/2" x 8" HRMS plate (Steel of different dimensions may be substituted.)
* 3. Seven each - 1/8" x 14" AWS E6013 electrodes
4. Appropriate clothing

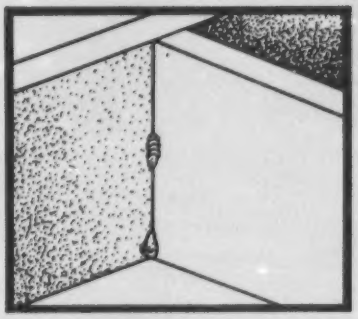


Figure 1

Procedure:

Step 1: Prepare the metal to be welded by removing any rust, scale, grease, etc., with a wire brush.

Step 2: Tack weld the two pieces of metal together. Place a tack weld in the center of the joint, then tack the right end, where the weld will finish. Then fasten the tacked pieces in the vertical position. (Refer to Figure 1.)

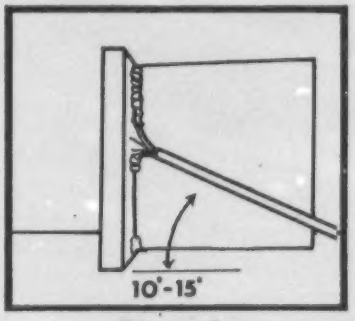


Figure 2

Step 3: Complete the required exercise in vertical down fillet welding.

a) Hold the electrode at a lead angle of 10 to 15 degrees. (Refer to Figure 2.) The work angle should be 45 degrees. (Refer to Figure 3.) If metal of uneven thickness is being used, change the work angle to point more heat at the thicker piece.

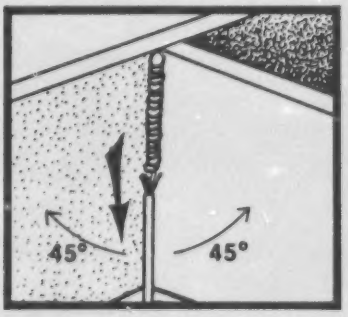


Figure 3

*** Additional electrodes may be needed if steel of different dimensions is substituted.**

b) Starting at the top of the seam, strike the arc and deposit a bead in the root of the seam. Move straight down using no weaving motion. (Refer to Figure 4.)

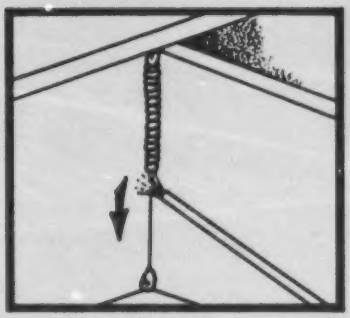


Figure 4

Step 4: Turn the welder off and lay the electrode holder aside.

Step 5: Cool the weld, break it, and check the weld for fusion and penetration. (Do not attempt to break a weld that is hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place the weld in the test equipment so that the result is to flatten the "V."
   2) When the welded joint breaks, examine the weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.

b) Destruction testing using a vise.
   1) Place the weld in the vise so that as the vise is tightened it flattens the "V", breaking the weld.
   2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 7: Reuse the practice metal. You should be able to get four separate welds for each two pieces of practice metal. (When you have a weld with satisfactory surface appearance and penetration, allow the weld to air-cool for greater strength. Hand in to the instructor when requested.)

UNIT - ARC WELDING

SHOP DEMONSTRATION #4: Vertical Up Fillet Welding

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise of vertical up fillet welding.

Tools Needed:

1. AC arc welder
2. Helmet
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Chipping hammer

Materials Needed:

1. One each - 3/8" x 4" x 8" HRMS plate
2. One each - 3/8" x 1-1/2" x 8" HRMS plate (Steel of different dimensions may be substituted.)
* 3. Seven each - 1/8" x 14" AWS E6013 electrodes
4. Appropriate clothing

Procedure:

Step 1: Demonstrate proper metal preparation for welding using a wire brush.

Step 2: Demonstrate tack welding the two pieces of metal together. Place a tack weld in the center of the joint, then tack the right end, where the weld will finish. Then demonstrate fastening the tacked pieces in the vertical position.

Step 3: Demonstrate how students will complete the required exercise in vertical up fillet welding.

a) Start the weld by holding the electrode at right angles to the plate while striking the arc.
b) Lower the rear of the electrode until the electrode forms an angle with the work of 10 to 15 degrees.
c) As the metal is deposited, move the tip of the electrode upward using wrist action motion. (DO NOT break the arc while using the rocking motion.) Rock the electrode upward just long enough to allow the deposited metal to solidify and form a shelf so that additional metal can be deposited.
d) Rock the electrode back down to the crater and repeat the operation, continuing until completion of the weld.

*** Additional electrodes may be needed if steel of different dimensions is substituted.**

Step 4: Demonstrate safe procedures in turning the welder off and laying the electrode holder aside.

Step 5: Demonstrate how to safely cool the weld, how to break it, and how to check the fusion and penetration. (Do not attempt to break a weld that is hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place the weld in the testing equipment so that the result is to flatten the "V."
   2) When the welded joint breaks, examine the weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.

b) Destruction testing using vise.
   1) Place the weld in the vise so that as the vise is tightened it flattens the "V", breaking the weld.
   2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 6: Demonstrate reusing the pieces of metal for continued practice.

UNIT - ARC WELDING

SHOP EXERCISE #3: Vertical Up Fillet Welding

Objective: At the end of this exercise, the student should be able to weld a vertical up fillet weld.

Tools Needed:

1. AC arc welder
2. Helmet
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Chipping hammer

Materials Needed:

1. One each - 3/8" x 4" x 8" HRMS plate
2. One each - 3/8" x 1-1/2" x 8" HRMS plate (Steel of different dimensions may be substituted.)
* 3. Seven each - 1/8" x 14" AWS E6013 electrodes
4. Appropriate clothing

Procedure:

Step 1: Prepare the metal to be welded by removing any rust, scale, grease, etc., with a wire brush.

Step 2: Tack weld the two pieces of metal together. Place a tack weld in the center of the joint, then tack the right end, where the weld will finish. Then fasten the tacked pieces in the vertical position. (Refer to Figure 1.)

Step 3: Complete the required exercise in verticle up fillet welding.

a) Start the weld by holding the electrode at right angles to the plate while striking the arc. (Refer to Figure 2.) Hold a work angle of 45 degrees. (Refer to Figure 3.)

b) Lower the rear of the electrode until the electrode forms an angle with the work of 10 to 15 degrees. (Refer to Figure 4.)

*** Additional electrodes may be needed if steel of different dimensions is substituted.**

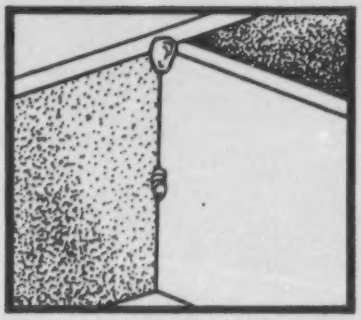


Figure 1

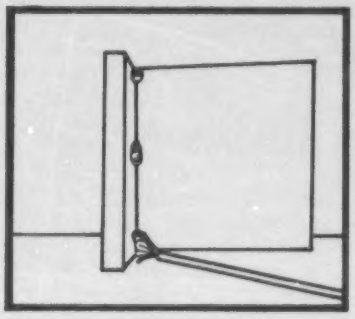


Figure 2

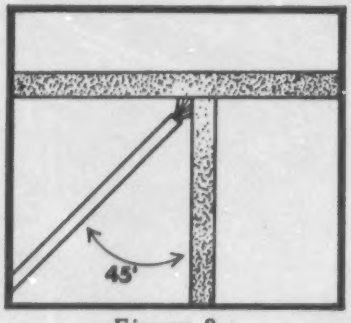


Figure 3

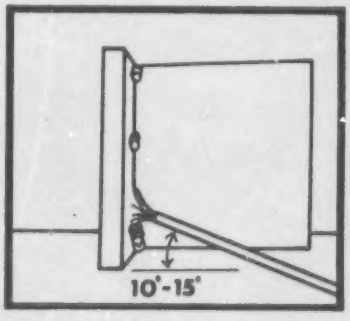


Figure 4

c) As the metal is deposited, move the tip of the electrode upward using wrist action motion. (DO NOT break the arc while using the rocking motion.) Rock the electrode upward just long enough to allow the deposited metal to solidify and form a shelf so that additional metal can be deposited. (Refer to Figure 5.)

d) Rock the electrode back down to the crater and repeat the operation, continuing until completion of the weld.

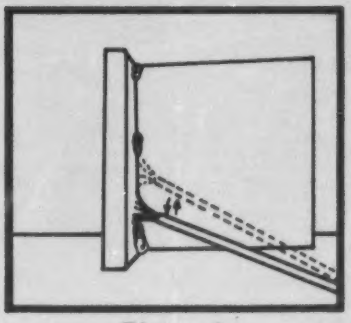


Figure 5

Step 4: Turn the welder off and lay the electrode holder aside.

Step 5: Cool the weld, break it, and check the weld for fusion and penetration. (Do not attempt to break a weld that is hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place the weld in the testing equipment so that the result is to flatten the "V."
   2) When the welded joint breaks, examine the weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.

b) Destruction testing using vise.
   1) Place the weld in the vise so that as the vise is tightened, it flattens the "V", breaking the weld.
   2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 6: Reuse the practice metal. You should be able to get four separate welds for each two pieces of practice metal. (When you have a weld with satisfactory surface appearance and penetration, allow the weld to air-cool for greater strength. Hand in to the instructor when requested.)

UNIT - OXY-ACETYLENE WELDING

Lesson 1: What safety practices should I follow while using the oxy-acetylene unit?

Objective: At the end of this lesson, the student will be able to follow basic safety practices when using the oxy-acetylene unit.

Study Questions:

1. **What hazards exist for the operator and others during the use of the oxy-acetylene unit?**

2. **What can I do to protect myself while using the oxy-acetylene unit?**

3. **How can I avoid fires and explosions while using the oxy-acetylene unit?**

References:

1. Power Tool Safety and Operation, Hoerner and Betti, pp. 93-96.

2. Oxy-acetylene Brazing, Cutting, and Welding, Instructor's Manual, Smith Equipment, Lessons I and II.

3. Welding Skills and Practices, Giachino, Weeks, and Brune, Chapters 22 and 23.

4. Modern Agricultural Mechanics, Wakeman, Chapter 8.

5. Shopwork on the Farm, Jones, Chapter 17.

UNIT - OXY-ACETYLENE WELDING

Lesson 1: What safety practices should I follow while using the oxy-acetylene unit?

TEACHING PROCEDURES

A. Review

B. Motivation: Ask the students what would happen if the valve on the top of a full oxygen cylinder were suddenly knocked off. (The 2200 psi would cause the cylinder to take off like a rocket, attaining a speed of over 200 mph within the first second.) Guide the discussion toward the conclusion that the oxy-acetylene unit is one of the most dangerous tools in the shop, but is safe when used properly.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students what hazards exist for the operator and others during the use of the oxy-acetylene unit.

   What hazards exist for the operator and others during the use of the oxy-acetylene unit?

   1) Burns
   2) Harmful light rays
   3) Harmful fumes
   4) Fires and explosions

2. Ask the students what they can do to protect themselves whiie using the oxy-acetylene unit.

   What can I do to protect myself while using the oxy-acetylene unit?

   1) Always wear oxy-acetylene goggles when welding or cutting. Lenses should be shade 5 or 6 for most applications.
   2) Wear fire resistant gloves and clean coveralls without cuffs.
   3) Wear high-topped shoes or boots (never tennis shoes) while using the oxy-acetylene unit.
   4) Do not weld or cut unless there is adequate ventilation.
   5) Do not cut galvanized metal indoors as a toxic gas is given off.
   6) Never open the acetylene tank valve more than 1/3 to 1/2 turn so that the tank can be shut off quickly in case of fire.
   7) Never use oxygen as a substitute for compressed air.
   8) Put remaining ends of welding rods in a suitable container. Do not drop them on the floor.
   9) Never light the torch with a match.
   10) Open each cylinder valve slowly.
   11) Never withdraw more than 1/7 of the contents of the acetylene cylinder per hour.
   12) Avoid leaving hot metal where others may be burned by it. If the

metal cannot be cooled before you leave the shop, chalk the word "HOT" on the metal in large letters where others can plainly see.

3. Ask the students how they can avoid fires and explosions while using the oxy-acetylene unit.

How can I avoid fires and explosions while using the oxy-acetylene unit?

1) Never wear oily or greasy coveralls while oxy-acetylene welding or cutting.
2) Clear the area of all flammable materials before lighting the torch.
3) Never cut or weld a container until it has been made safe.
4) Never use oil or grease around the oxygen cylinder, regulator, or torch.
5) Position the metal to be welded so that no stray sparks will go toward the hoses or cylinders.
6) Point the torch away from the cylinders and away from others when lighting.
7) Use soap suds to check hoses and connections for leaks before using.
8) Keep the protective caps on any cylinders not in use. Cylinders not in use should be secured in an upright position, chained to a wall, with a fireproof wall separating the oxygen and acetylene cylinders.
9) Never use torches, regulators, or other equipment that is in need of repair.
10) Never use acetylene at pressures above 15 pounds per square inch (psi).
11) Leave the acetylene tank wrench valve in place at all times when the valve is open, so that the tank can be shut off quickly in case of fire.
12) In case of flashback, allow the torch to cool, then find the cause of the flashback and correct it before resuming work.

F. Other Activities

The teacher may wish to utilize the activity sheet on the Oxy-acetylene Welder from the Power Tool Safety and Operation Instructor Packet by HOBAR (also available from the Instructional Materials Laboratory) as a part of this lesson.

G. Summary

To use the oxy-acetylene unit safely, the student should:

1. Wear the proper protective clothing and shoes including oxy-acetylene goggles with lenses of shade 5 or 6.
2. Never cut or weld without proper ventilation.
3. Clear the area of all flammable materials before lighting the torch.
4. Maintain the equipment properly, using no oil on the threads or connections, and never using the unit if the hoses, regulators, etc., are in poor condition..

H. Answers to Evaluation

(NOTE: The teacher may also want to administer the HOBAR Oxy-Acetylene Welder Safety Exam as an additional evaluation for this lesson. These exams are available in pad form from the Instructional Materials Laboratory.)

1. T
2. F
3. F
4. T
5. T
6. F
7. F
8. T
9. T
10. T

UNIT - OXY-ACETYLENE WELDING

Lesson 1: What safety practices should I follow while using the oxy-acetylene unit?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. The acetylene tank valve should never be opened more than 1/3 to 1/2 turn.

T F 2. Untreated, plain cotton gloves would be ideal for use while oxy-acetylene welding.

T F 3. When a flashback occurs, you should relight the torch immediately and continue the work.

T F 4. When lighting the torch, always point the torch away from yourself and others.

T F 5. Always leave the acetylene tank valve wrench in place while the valve is open.

T F 6. Because of the higher pressures, compressed oxygen in cylinders is perfect for cleaning dust and dirt from tables and other objects.

T F 7. Low-topped leather shoes are adequate protection for the feet while using the oxy-acetylene unit.

T F 8. Cylinders not in use should be stored in an upright position, chained to a wall, with a fireproof wall separating the oxygen and acetylene cylinders.

T F 9. Hazards which exist from use of the oxy-acetylene unit include harmful fumes, burns, harmful light rays, and fires and explosions.

T F 10. Never drop remaining ends of welding rods on the floor.

UNIT - OXY-ACETYLENE WELDING

Lesson 2: How can I fusion weld with oxy-acetylene?

Objective: At the end of this lesson, the student will be able to fusion weld light material using oxy-acetylene equipment.

Study Questions

1. **What is a welding puddle?**
2. **When should a filler rod be used for oxy-acetylene fusion welding?**
3. **How should I set up the equipment for fusion welding?**
4. **What procedures should I follow when fusion welding with oxy-acetylene?**
5. **What are some common problems I should try to avoid?**

References:

1. Oxy-acetylene Brazing, Cutting and Welding, Instructor's Manual, Smith Equipment, Lessons III-VI.
2. Welding Skills and Practices, Giachino, Weeks, and Brune, Chapters 22, 23, and 24.
3. Modern Agricultural Mechanics, Wakeman, Chapter 8.
4. Shopwork on the Farm, 2nd Ed., Jones, Chapter 17.
5. Transparency Masters
   a. TM-1: Oxy-acetylene Tip Size and Working Pressures
   b. TM-2: Controlling Distortion When Fusion Welding
   c. TM-3: Angles for Welding
   d. TM-4: Testing Weld Strength
   e. TM-5: Characteristics of Good and Bad Welded Joints
6. Handout
   a. HO-1: Oxy-acetylene Tip Size and Working Pressures
7. Shop Demonstrations
   a. #1: Running a Puddle
   b. #2: Butt Welding in the Flat Position
   c. #3: Corner Welding in the Flat Position
8. Shop Exercises
   a. #1: Running a Puddle
   b. #2: Butt Welding in the Flat Position
   c. #3: Corner Welding in the Flat Position

UNIT - OXY-ACETYLENE WELDING

Lesson 2: How can I fusion weld with oxy-acetylene?

TEACHING PROCEDURES

A. Review

At the start of this lesson, review with the class points learned in Animal Science Agricultural Mechanics, especially:

1. Equipment used.
2. Types of flames in oxy-acetylene.
3. Setting oxygen and acetylene pressures and lighting the torch.
4. Shutting off and securing the equipment when finished.

B. Motivation: Bring to class several examples of light metal (less then 1/8-inch thick) welded with an arc welder and with an oxy-acetylene welder. The examples should show the advantages of using oxy-acetylene fusion welding on light material. Ask the students why oxy-acetylene can be used to advantage on light material.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students what a welding puddle is.

What is a welding puddle?

1) The puddle is a pool of molten metal formed by melting the base metal.

2. Ask the students when a filler rod should be used in fusion welding with oxy-acetylene.

When should a filler rod be used for oxy-acetylene fusion welding?

1) Filler rod is used to reinforce and/or build up the weld.

3. Ask the students how to set up the oxy-acetylene unit for fusion welding. As the students suggest each step, list these on the board. Hand out HO-1 to the students. Show TM-1 to the students. Ask the students what sizes of tips to use for various thicknesses of metal. Pass tips of various

sizes around the room. Discuss the relationship between tip size and working pressures for oxygen and acetylene. When a list has been compiled and put in order, demonstrate the procedures on an oxy-acetylene unit.

How should I set up the equipment for fusion welding?

1) Select the correct tip for the metal thickness to be welded. (Refer to TM-1 and HO-1.)
2) Turn on the oxygen and acetylene tanks. Open oxygen tank valve all the way and the acetylene tank valve 1/3 to 1/2 turn.
3) Set working pressures on the regulators for the tip size selected. (Refer to TM-1 and HO-1.)

4. Ask the students what procedures to follow when fusion welding. Show TM-2 to the students. Ask the students what distortion is and how to control it. Show TM-3 to the students. Ask the students at what angle the tip should be to the work. Use a tip to demonstrate the proper angles. Show TM-4 to the students. Ask the students why it is important to test each practice weld.

What procedures should I follow when fusion welding with oxy-acetylene?

1) Clean the metal to be welded. Any rust or scale left on the base metal will fuse with the molten metal weakening the weld.
2) If welding two pieces together, space the pieces or tack weld to control distortion due to expansion and contraction. When tack welding, space the two pieces evenly, place the first tack weld at the center of the area to be welded, then tack the end where the weld will finish. Tack welding the center first will hold the pieces evenly spaced for further welding and prevent distortion when tack welding. (Refer to TM-2.)
3) Set up the equipment for welding. Then light the torch and adjust to a neutral flame.
4) Hold the welding tip at a 45-degree angle to the work. (Refer to TM-3.) Hold the tip so the end of the inner cone is approximately 1/8-inch from the work. Point the flame at the work until a puddle of molten metal is formed.
5) While waiting for the puddle to form, heat the end of the welding rod until it is white-hot by holding it in the outer envelope of the flame. Use a filler rod of the same metallic composition and approximately the same diameter as the thickness of the metal to be welded.
6) Move the puddle forward, dipping the end of the rod in and out of the puddle. Keep the end of the rod white-hot by keeping it in the outer envelope of flame when the rod is not in contact with the puddle.
7) When finished with the bead, shut down the equipment.
8) When practicing, metal should be cooled between beads and the welds broken. (Refer to TM-4.) Cool the base metal to dissipate built-up heat so that the base metal is approximately the same temperature as each bead is run. Welds should be broken so that fusion and penetration can be examined.

9) When the student has welds ready to turn in for a grade, the weld should be allowed to cool as slowly as possible to give it more strength.

5. Ask the students what problems they may face as beginning oxy-acetylene welders. Show TM-5 to the students. Ask the students what caused each of the improper welds.

What are some common problems I should try to avoid?

1) Backfire - the flame goes out, accompanied by loud pop.
   a) Possible causes:
      (1) Overheating the tip, by holding the tip too close to the work.
      (2) Operating the torch at lower pressures than required for the tip used.
      (3) Touching the tip against the work.
      (4) A loose tip or head.
      (5) Dirt on the seat.
   b) In case of backfire, shut off the torch valves, remedy the cause, then relight the torch and proceed. (For example, if the tip is overheated, use another tip or wait until the tip cools to proceed.)
2) Flashback - the flame flashes back into the torch and burns inside with a shrill hissing or squealing noise.
   a) A flashback is an indication of a more serious problem, either with the torch itself or with the way it is being operated.
   b) When a flashback occurs, shut off the torch valves immediately, allow the torch to cool, and investigate the cause before relighting the torch.
   c) A clogged orifice or improper oxygen and acetylene pressures are often responsible for flashbacks.
3) Improper flame adjustment.
   a) An oxidizing flame produces too much heat which causes the weld to be brittle.
   b) A carburizing flame causes wetting of the surface with shallow penetration. This adds carbon to the puddle which also results in a brittle weld.
4) Speed or penetration problems. (Refer to TM-5.)
   a) Uneven bead surface appearance, caused by an uneven rate of travel.
   b) Excessive reinforcement - traveling too slow with a tip that is too small.
   c) Lack of penetration - traveling too fast, resulting in not enough heat .
   d) Weld metal protruding - pieces of metal spaced too far apart.

F. Other Activities

Shop Demonstrations
- #1 - Running a Puddle
- #2 - Butt Welding in the Flat Position
- #3 - Corner Welding in the Flat Position

Shop Exercises

#1 - Running a Puddle
#2 - Butt Welding in the Flat Position
#3 - Corner Welding in the Flat Position

G. Summary

When fusion welding with oxy-acetylene, the student should:

1. Use safe procedures in setting up the equipment, lighting the torch, operating the equipment, and shutting down the equipment.
2. Select the correct tip for the thickness of metal to be welded.
3. Set oxygen and acetylene working pressures based on the tip size selected.
4. Control distortion by tack welding or through uneven spacing.
5. Manipulate the rod and flame to produce a bead with a uniform ripple pattern with adequate penetration.

H. Answers to Evaluation

1. T
2. F
3. T
4. F
5. T
6. F
7. T
8. T
9. T
10. T

UNIT - OXY-ACETYLENE WELDING

Lesson 2: How can I fusion weld with oxy-acetylene?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. When tack welding, space the pieces to be welded approximately half the thickness of the metal apart.

T F 2. Rusty metal can be fusion welded satisfactorily with no surface preparation.

T F 3. The welding tip should be held at a 45-degree angle to the work, with 1/8-inch distance between the end of the inner cone and the work.

T F 4. A carburizing flame is used for most oxy-acetylene fusion welding.

T F 5. A welding rod is used to provide extra metal to reinforce and build up the weld.

T F 6. When setting up the oxy-acetylene equipment, both the oxygen and acetylene tank valves should be opened all the way.

T F 7. Distortion in oxy-acetylene welding can be controlled through tack welding or by uneven spacing of the pieces to be welded.

T F 8. Filler rod for welding 1/8-inch metal should be approximately 1/8-inch in diameter.

T F 9. Overheating of the tip caused by holding the tip too close to the work can cause a backfire.

T F 10. Use of improper oxygen and acetylene pressures can cause a flashback.

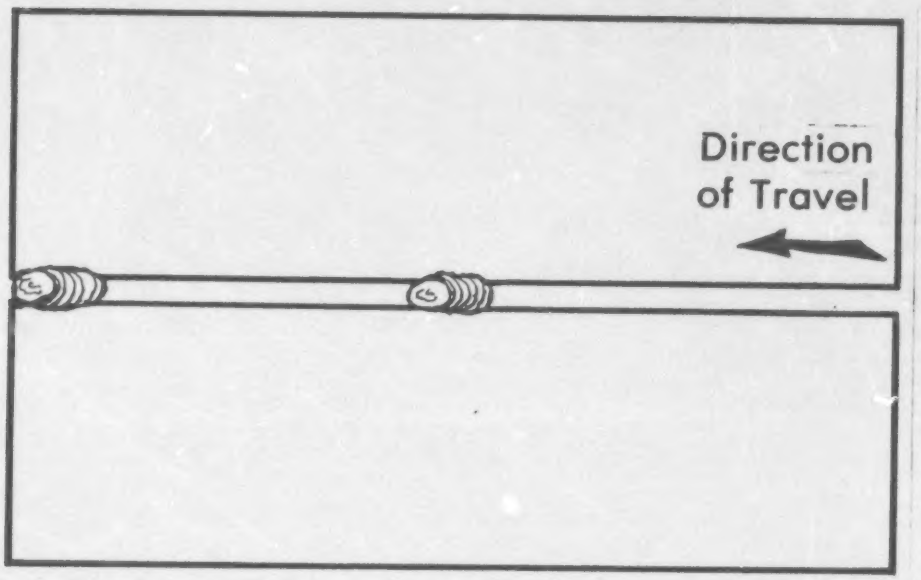
Oxy-acetylene Tip Size and Working Pressures

Metal Thickness	Tip Size	Oxygen Pressure P.S.I.G.		Acetylene Pressure P.S.I.G.	
		Min.	Max.	Min.	Max.
up to 1/32"	000	1	2	1	2
1/64" - 3/64"	00	1	2	1	2
1/32" - 5/64"	0	1	3	1	3
3/64" - 3/32"	1	2	4	2	4
1/16" - 1/8"	2	3	5	2	5
1/8" - 3/16"	3	4	7	3	6
3/16" - 1/4"	4	5	10	4	7
1/4" - 1/2"	5	6	12	5	8

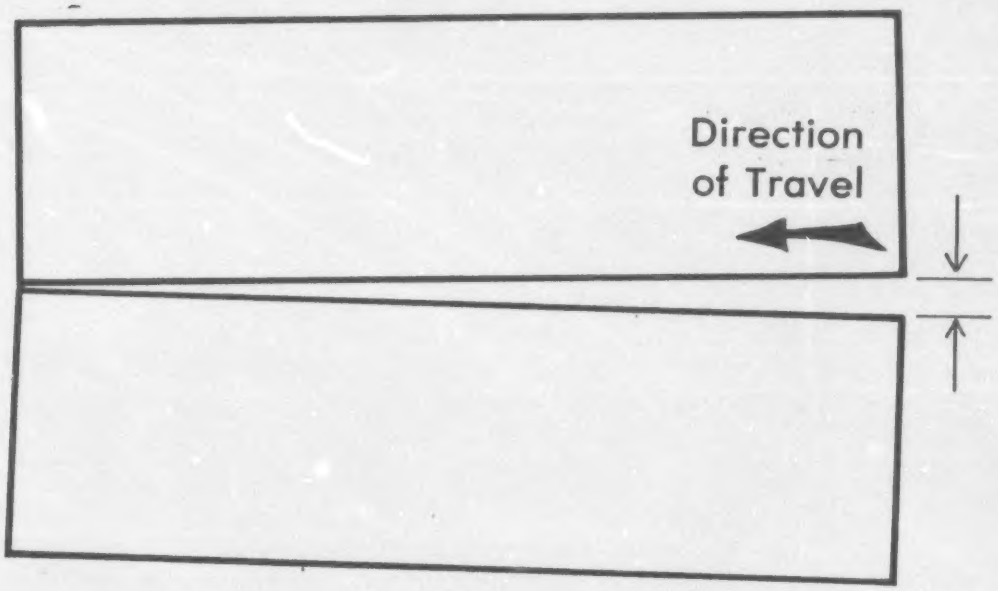
Courtesy Victor Equipment Company

Controlling Distortion When Fusion Welding

TM-2



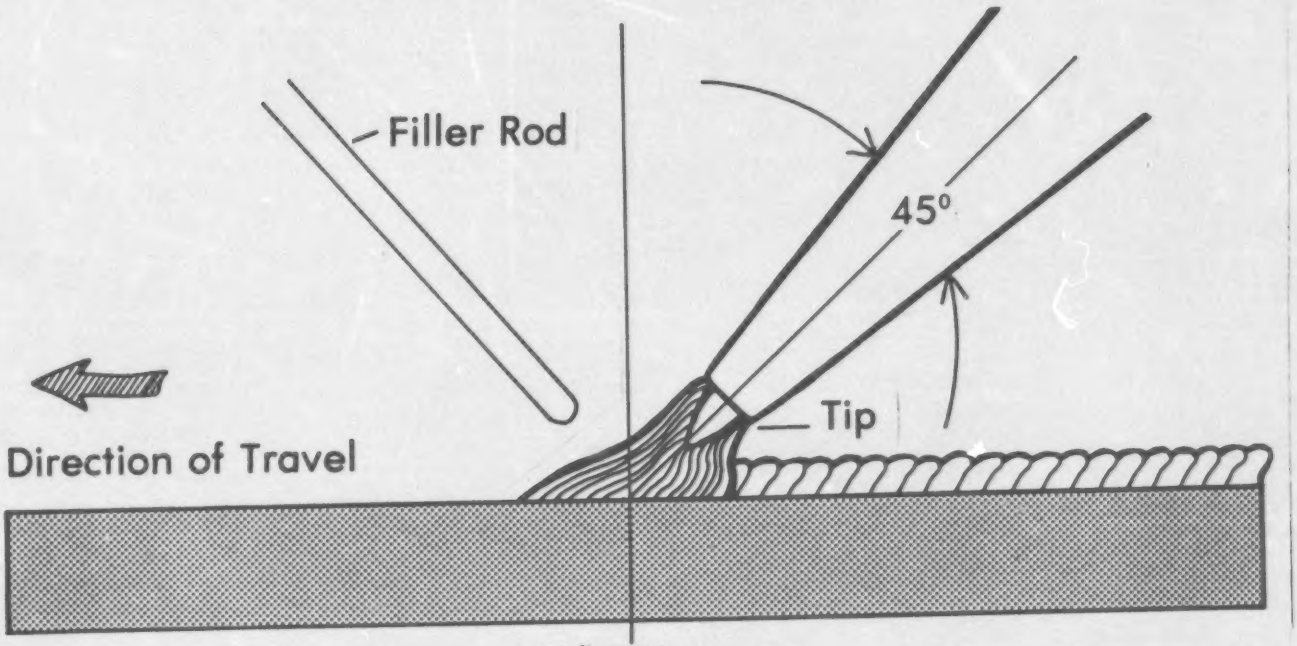
Tacking Two Pieces Together Before Welding



Allowing Space

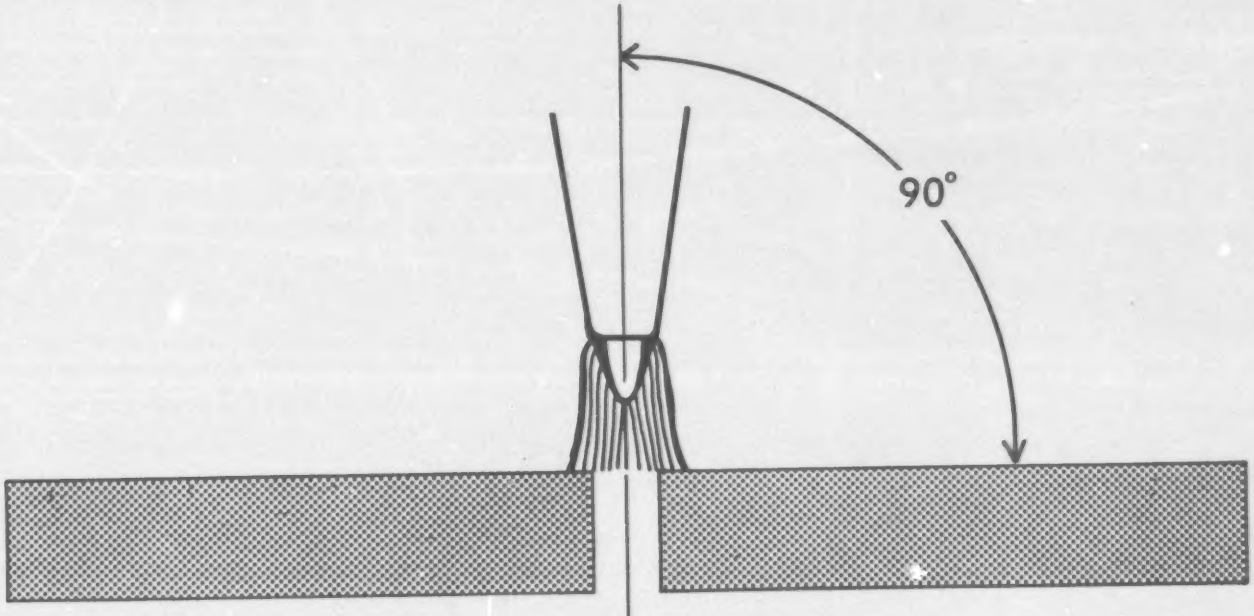
TM-3

Angles For Welding



Side View

Lead Angle



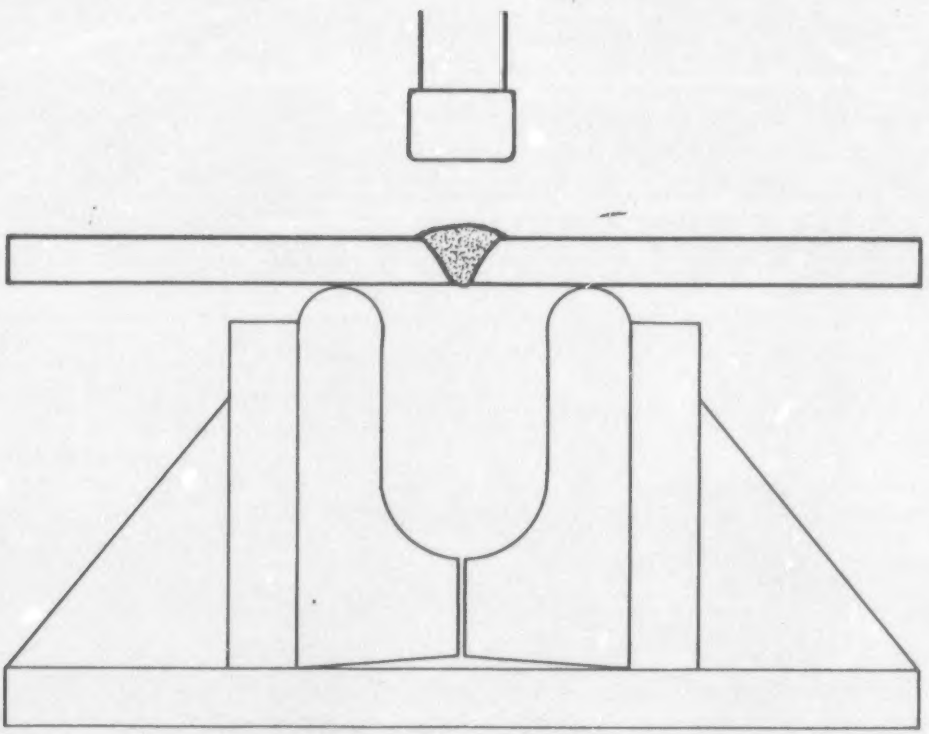
End View

Working Angle

Testing Weld Strength

TM-4

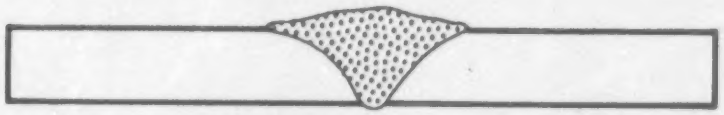
Testing With Hammer and Vise



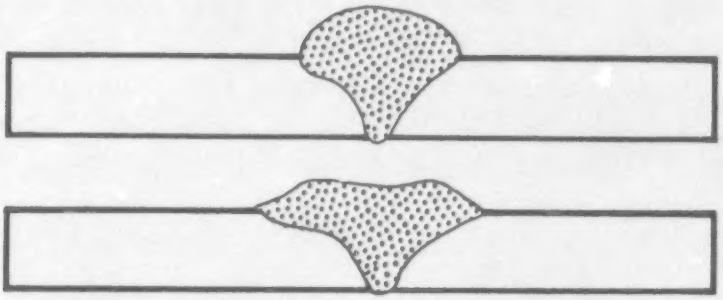
Guided Bend Test

Characteristics of Good and Bad Welded Joints

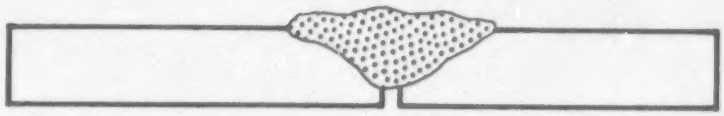
TM-5



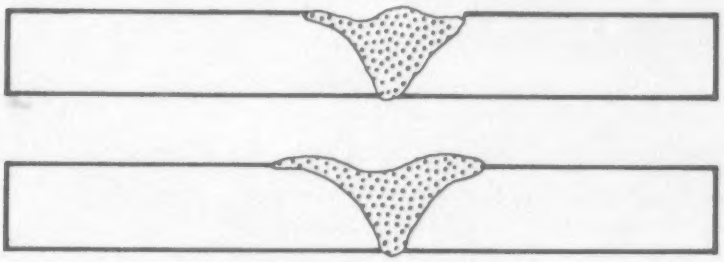
Correct Weld Contour



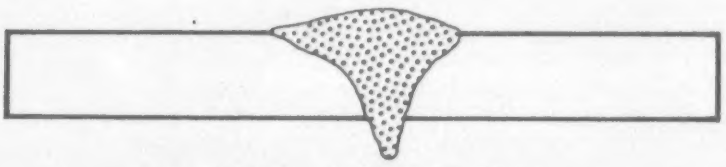
Excessive Reinforcement



Lack of Penetration



Undercutting or "Valleys"



Weld Metal Protruding

UNIT - OXY-ACETYLENE WELDING

SHOP DEMONSTRATION #1: Running a Puddle

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercises in running a puddle with and without a filler rod.

Tools Needed:

1. Oxy-acetylene welding unit, with #3 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush

Materials Needed:

1. One each - 1/8" x 4" x 8" hot rolled mild steel (HRMS) plate (Steel of different dimensions may be substituted.)
* 2. Two each - 1/8" x 36" No. 7 welding rod (Using pliers, bend one end of each rod into a "shepherd's crook." This will help prevent eye injuries and will also indicate which end of the rod is cool and can be picked up. Do not cut the rods.)

Procedure:

Step 1: Demonstrate proper metal preparation for welding using a wire brush.

Step 2: Demonstrate marking off lines to follow while running a puddle.

Step 3: Demonstrate how to safely set up equipment for welding, how to light the torch, and how to adjust to a neutral flame. (Refer to TM-1 for proper oxygen and acetylene working pressures.)

a) Check the torch valves to make sure that they are closed.
b) Open the oxygen tank valve full open until the valve is tight against the upper seat.
c) Open the acetylene tank valve 1/3 turn.
d) Open the oxygen torch valve and set the appropriate working pressure for the tip size used. (For a #3 tip, oxygen working pressure should be 4 to 7 pounds as shown on TM-1. Check the operator's manual for proper pressures for your equipment.)
e) Close the oxygen torch valve.
f) Open the acetylene torch valve and set the appropriate working pressure. (For a #3 tip, acetylene working pressure should be 3 to 6 pounds.)
g) Close the acetylene torch valve.
h) Open the acetylene torch valve 1/8 turn.
i) Pointing the torch away from you, hold a sparklighter at the end of the tip and strike a spark to ignite the acetylene.

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

j) Open the valve until there is a 1/8-inch gap between the end of the tip and the start of the flame.
k) Close the acetylene torch valve slightly to bring the flame back to the end of the tip.
l) Open the oxygen torch valve slowly until a neutral flame is reached.

Step 4: Demonstrate how students will complete the required exercise in running a puddle without rod.

a) Point the flame at a spot just inside the right edge of the metal. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the work.
b) Hold this position until a pool of molten metal is formed.
c) Move the torch in a series of arcs or circles so that the puddle becomes circular in shape and about 1/4-inch in diameter.
d) Following the scribed line, move the torch forward at a speed that will keep the puddle uniform in size and shape.
e) Cool the metal to dissipate built-up heat.
f) Repeat the above steps following another scribed line.

Step 5: Demonstrate how students will complete the required exercise in running a puddle with rod.

a) Measure the length of the welding rod prior to beginning the weld. During the welding process, keep in mind that one inch of rod should make one inch of bead.
b) Point the flame at a spot just inside the right edge of the metal. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the work.
c) Hold this position until a pool of molten metal is formed.
d) While waiting for the puddle to form, heat the end of the welding rod by holding it in the outer envelope of the flame. Heat until the tip of the rod is white-hot.
e) Move the puddle forward following the scribed line, dipping the end of the rod in and out of the puddle. Keep the end of the rod hot by keeping it in the outer envelope of flame when the rod is not in contact with the puddle.
f) Shut off acetylene and oxygen torch valves and lay the torch aside, being careful not to let the hoses, torch, or other equipment come in contact with any hot metal that may damage the equipment.
g) Cool the metal to dissipate the built-up heat.
h) To determine if the correct speed of travel was used, remeasure the welding rod after it has cooled to find out how much rod was used on that bead. If the bead was 8" long, 8" of welding rod should have been used. If less than 8" of welding rod was used, then the speed of travel was too fast. The speed of travel was too slow if more than 8" of welding rod was used.
i) Repeat the above steps following another scribed line.

Step 6: Demonstrate safe procedures in shutting off the torch and putting up the equipment.

a) Close the acetylene torch valve.
b) Close the oxygen torch valve.
c) Shut off the oxygen and acetylene tank valves.
d) Open the acetylene torch valve to purge the line.
e) When both the cylinder pressure gauge and the working pressure gauge register 0 (zero) close the acetylene torch valve.
f) Open the oxygen torch valve to purge the line.
g) When both the cylinder pressure gauge and the working pressure gauge register 0 (zero) close the oxygen torch valve.
h) Release the pressure on the oxygen and acetylene regulator diaphragms by turning each one counterclockwise until the tension is released.
i) Coil hoses neatly and put up the sparklighters and other equipment.

UNIT - OXY-ACETYLENE WELDING

SHOP EXERCISE #1: Running a Puddle

Objective: At the end of this exercise, the student should be able to run a puddle with and without rod.

Tools Needed:

1. Oxy-acetylene welding unit, with #3 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush

Materials Needed:

1. One each - 1/8" x 4" x 8" hot rolled mild steel (HRMS) plate (Steel of different dimensions may be substituted.)
* 2. Two each - 1/8" x 36" No. 7 welding rod (Using pliers, bend one end of each rod into a "shepherd's crook." This will help prevent eye injuries and will also indicate which end of the rod is cool and can be picked up. Do not cut the rods.) (Refer to Figure 1.)

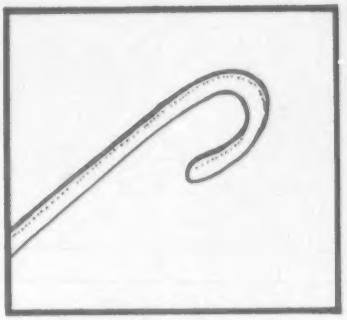


Figure 1

Procedure:

Step 1: Prepare the metal to be welded by cleaning it with a wire brush.

Step 2: Using a scratch awl or a center punch, lay off a series of lines 1/2-inch apart on both sides of the metal plate.

Step 3: Set up the welding equipment; then light the torch, adjusting to a neutral flame.

a) Check the torch valves to make sure that they are closed.
b) Open the oxygen tank valve full open until the valve is tight against the upper seat.
c) Open the acetylene tank valve 1/3 turn.

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

d) Open the oxygen torch valve and set the appropriate working pressure for the tip size used. (For a #3 tip, oxygen working pressure should be 4 to 7 pounds as shown on HO-1. Check the operator's manual for proper pressures for your equipment.)
e) Close the oxygen torch valve.
f) Open the acetylene torch valve and set the appropriate working pressure. (For a #3 tip, acetylene working pressure should be 3 to 6 pounds.)
g) Close the acetylene torch valve.
h) Open the acetylene torch valve 1/8 turn.
i) Pointing the torch away from you, hold a sparklighter at the end of the tip and strike a spark to ignite the acetylene.
j) Open the valve until there is a 1/8-inch gap between the end of the tip and the start of the flame.
k) Close the acetylene torch valve slightly to bring the flame back to the end of the tip.
l) Open the oxygen torch valve slowly until a neutral flame is reached.

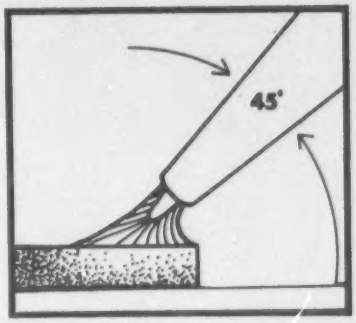


Figure 2

Step 4: Run a puddle without a rod. (Run all puddles without rod on the same side of the plate.)

a) Point the flame at a spot just inside the right edge of the metal. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the work. (Refer to Figures 2 and 3.)
b) Hold this position until a pool of molten metal is formed.
c) Move the torch in a series of arcs or circles so that the puddle becomes circular in shape and about 1/4-inch in diameter.
d) Following the scribed line, move the torch forward at a speed that will keep the puddle uniform in size and shape. (Refer to Figure 4.)
e) Cool the metal to dissipate built-up heat.

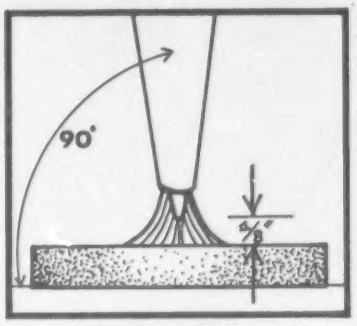


Figure 3

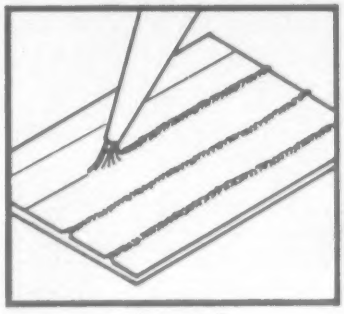


Figure 4

f) Repeat the above steps following another scribed line until all lines have been welded.

Step 5: Turn the plate over and run puddles with rod on this side of the plate.

a) Measure the length of the welding rod prior to beginning the weld. During the welding process, keep in mind that one inch of rod should make one inch of bead.

b) Point the flame at a spot just inside the right edge of the metal. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the work. (Refer to Figures 5 and 6.)

c) Hold this position until a pool of molten metal is formed.

d) While waiting for the puddle to form, heat the end of the welding rod by holding it in the outer envelope of the flame. Heat until the tip of the rod is white-hot.

e) Move the puddle forward following the scribed line, dipping the end of the rod in and out of the puddle. (Refer to Figure 7.) Keep the end of the rod hot by keeping it in the outer envelope of flame when the rod is not in contact with the puddle. (Refer to Figure 8.)

f) Shut off acetylene and oxygen torch valves and lay the torch aside, being careful not to let the hoses, torch, or other equipment come in contact with any hot metal that may damage the equipment.

g) Cool the metal to dissipate the built-up heat.

h) To determine if the correct speed of travel was used, remeasure the welding rod after is has cooled to find out how much rod was used on that bead. If the bead was 8" long, 8" of welding rod should have been used. If less than 8" of welding rod was used, then the speed of travel was too fast. The speed of travel was too slow if more than 8" of welding rod was used.

i) Repeat the above steps following another scribed line.

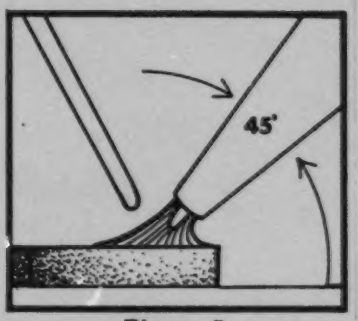


Figure 5

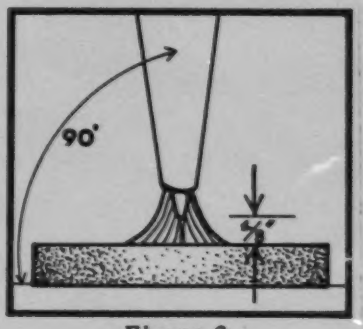


Figure 6

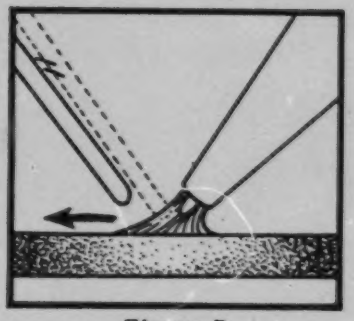


Figure 7

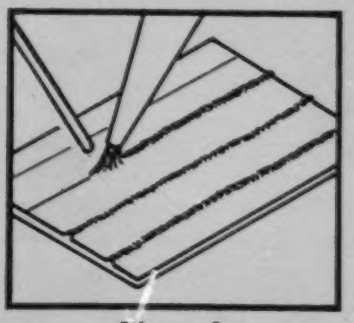


Figure 8

Step 6: When finished welding for the period, shut down the equipment.

a) Close the acetylene torch valve.
b) Close the oxygen torch valve.
c) Shut off the oxygen and acetylene tank valves.
d) Open the acetylene torch valve to purge the line.
e) When both the cylinder pressure gauge and the working pressure gauge register 0 (zero), close the acetylene torch valve.
f) Open the oxygen torch valve to purge the line.
g) When both the cylinder pressure gauge and the working pressure gauge register 0 (zero), close the oxygen torch valve.
h) Release the pressure on the oxygen and acetylene regulator diaphragms by turning each adjusting screw counterclockwise until the tension is released.
i) Coil hoses neatly and put up the sparklighters and other equipment.

UNIT - OXY-ACETYLENE WELDING

SHOP DEMONSTRATION #2: Butt Welding in the Flat Position

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise of butt welding in the flat position.

Tools Needed:

1. Oxy-acetylene welding unit, with #3 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Weld testing equipment (weld test machine, or vise and ball-peen hammer or large crescent wrench)

Materials Needed:

1. Two each - 1/8" x 4" x 8" HRMS plate (Steel of different dimensions may be substituted.)
* 2. Two each - 1/8" x 36" No. 7 welding rod (Bend one end of each rod into a "shepherd's crook." Do not cut the rods.)

Procedure:

Step 1: Demonstrate proper metal preparation for welding using a wire brush.

Step 2: Demonstrate how to space the metal to be welded. Use uneven spacing, or if tack welding is to be used, space the metal with an even spacing of approximately half the thickness of the pieces.

Step 3: Demonstrate how to safely set up the equipment for welding and how to light the torch, adjusting to a neutral flame. (See Shop Demonstration #1 for these procedures.). Refer to TM-1 for proper oxygen and acetylene working pressures.

Step 4: Demonstrate how students will complete the required exercise in butt welding in the flat position.

a) If pieces are to be tack welded, space the two pieces evenly, place the first tack weld at the center of the area to be welded, then tack the end where the weld will finish. Tack by holding the torch at a 45-degree angle to the joint and play the flame on the two edges. Deposit metal until the tack is approximately 1/4-inch in diameter.

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

b) Point the flame at a spot just inside the right edge of the joint. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the end of the work.
c) Hold this position until a pool of molten metal is formed.
d) While waiting for the puddle to form, heat the end of the welding rod by holding it in the outer envelope of the flame. Heat until the tip of the rod is white-hot.
e) Move the puddle forward along the joint, dipping the end of the rod in and out of the puddle. Keep the end of the rod hot by keeping it in the outer envelope of flame when the rod is not in contact with the puddle.

Step 5: Demonstrate safe procedures in shutting off the torch and putting up the equipment. (Refer to Shop Demonstration #1 for these procedures.)

Step 6: Demonstrate how to safely cool the weld, how to break it, and how to check fusion and penetration. (Do not attempt to break a weld that is hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place welded side up so that the press pushes down against it.
   2) When the welded joint breaks, examine the weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.
b) Destruction testing using vise and hammer/crescent wrench.
   1) Place welded side away from you so that the force is applied against the stationary jaw of the vise.
   2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 7: Demonstrate reusing the pieces of metal for continued practice.

UNIT - OXY-ACETYLENE WELDING

SHOP EXERCISE #2: Butt Welding in the Flat Position

Objective: At the end of this exercise, the student will be able to butt weld in the flat position.

Tools Needed:

1. Oxy-acetylene welding unit, with #3 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Weld testing equipment (weld test machine, or vise and ball-peen hammer or large crescent wrench)

Materials Needed:

1. Two each - 1/8" x 4" x 8" HRMS plate (Steel of different dimensions may be substituted.)
* 2. Two each - 1/8" x 36" No. 7 welding rod (Bend one end of each rod into a "shepherd's crook." Do not cut the rods.)

Procedure:

Step 1: Prepare the metal to be welded by cleaning it with a wire brush.

Step 2: Space the metal to be welded with uneven spacing. If tack welding is to used, space the metal with an even spacing of approximately half the thickness of the pieces.

Step 3: Set up the equipment for welding. Light the torch and adjust to a neutral flame. (Refer to Shop Exercise #1 for a review of these procedures.) Refer to HO-1 for the proper oxygen and acetylene working pressures for the tip size used.

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

Step 4: Butt weld the pieces together.

a) If pieces are to be tack welded, space the two pieces evenly, place the first tack weld at the center of the area to be welded, then tack the end where the weld will finish. Tack by holding the torch at a 45-degree angle to the joint and play the flame on the two edges. Deposit metal until the tack is approximately 1/4-inch in diameter. (Refer to Figures 1 and 2.)

b) Point the flame at a spot just inside the right edge of the joint. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the work.

c) Hold this position until a pool of molten metal is formed.

d) While waiting for the puddle to form, heat the end of the welding rod by holding it in the outer envelope of the flame. Heat until the tip of the rod is white-hot. (Refer to Figure 3.)

e) Move the puddle forward along the joint, dipping the end of the rod in and out of the puddle. (Refer to Figures 4 and 5.) Keep the end of the rod hot by keeping it in the outer envelope of flame when the rod is not in contact with the puddle.

Step 5: Shut off the torch and put up the equipment. (Refer to Shop Exercise #1 for a review of these procedures.)

Step 6: Cool the weld; then break it to check penetration and metal fusion. (Do not try to break any weld hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place welded side up so that the press pushes down against it.
   2) When weld breaks, examine the weld. If weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.

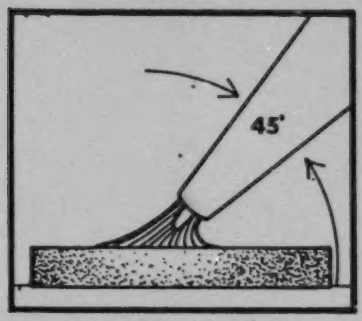


Figure 1

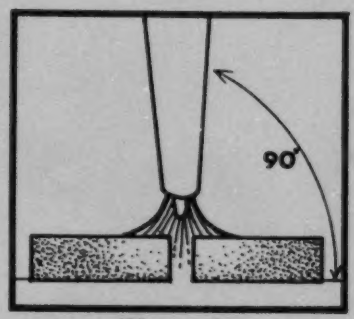


Figure 2

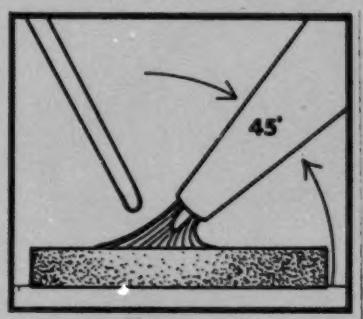


Figure 3

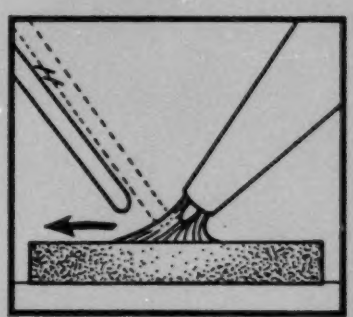


Figure 4

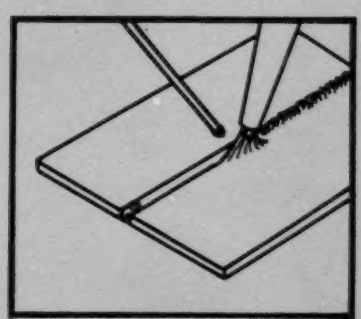


Figure 5

b) Destruction testing using vise and hammer/crescent wrench.
   1) Place welded side away from you so that the force is applied against the stationary jaw of the vise.
   2) If the weld breaks, inspection of the pieces should reveal that the metal has broken, not the weld.

Step 7: Reuse the practice metal. You should be able to get four separate welds for each two pieces of practice metal. (When you have a weld with satisfactory surface appearance and penetration, allow the weld to air-cool for greater strength. Hand in to the instructor when requested.)

UNIT - OXY-ACETYLENE WELDING

SHOP DEMONSTRATION #3: Corner Welding in the Flat Position

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise of corner welding in the flat position.

Tools Needed:

1. Oxy-acetylene welding unit, with #1 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Weld testing equipment (weld test machine, or vise)

Materials Needed:

1. Four each - 16 ga. x 2" x 3" HRMS plate (Steel of different dimensions may be substituted.)
* 2. Two each - 1/16" x 36" No. 7 welding rod (Bend one end of each rod into a "shepherd's crook." Do not cut the rods.)

Procedure:

Step 1: Demonstrate proper metal preparation for welding using a wire brush.

Step 2: Demonstrate how to set up the metal for welding the corner weld.

Step 3: Demonstrate how to safely set up the equipment for welding and light the torch, adjusting to a neutral flame. (See Shop Demonstration #1 for these procedures.) Refer to TM-1 for proper oxygen and acetylene pressures.

Step 4: Demonstrate how students will complete the required exercise of corner welding in the flat position without rod.

a) Space the two pieces evenly, place the first tack weld at the center of the area to be welded, then tack the end where the weld will finish. Hold the torch at a 45-degree angle to the joint and play the flame on the two edges. When the two pieces are fused together, move to the other end to start welding.
b) Point the flame at a point just inside the right edge of the joint. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the end of the work.
c) Hold this position until a puddle of molten metal is formed.
d) Move the puddle forward to the end of the weld.

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

Step 5: Demonstrate how students will complete the required exercise in corner welding in the flat position with rod.

a) Space the two pieces evenly, place the first tack weld at the center of the area to be welded, then tack the end where the weld will finish. Hold the torch at a 45-degree angle to the joint and play the flame on the two edges. When the two pieces are fused together, move to the other end to start welding.

b) Point the flame at a point just inside the right edge of the joint. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the end of the work.

c) Hold this position until a puddle of molten metal is formed.

d) While waiting for the puddle to form, heat the end of the welding rod by holding it in the outer envelope of the flame. Heat until the tip of the rod is white-hot.

e) Move the puddle forward along the joint to the end of the weld, dipping the end of the rod in and out of the puddle. Keep the end of the rod hot by keeping it in the outer envelope of flame when the rod is not in contact with the puddle.

Step 6: Demonstrate safe procedures in shutting off the torch and putting up the equipment. (Refer to Shop Demonstration #1 for a review of these procedures.)

Step 7: Demonstrate how to safely cool the weld, how to break it, and how to check the fusion and penetration. (Do not attempt to break a weld that is hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place welded side up so that the press pushes down against it, trying to flatten the "V".
   2) When the welded joint breaks, examine the weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.

b) Destruction testing using a vise.
   1) Place weld in the vise so that as the vise is tightened, it flattens the "V".
   2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 8: Demonstrate reusing the pieces of metal for continued practice.

UNIT - OXY-ACETYLENE WELDING

SHOP EXERCISE #3: Corner Welding in the Flat Position

Objective: At the end of this exercise, the student will be able to corner weld in the flat position.

Tools Needed:

1. Oxy-acetylene welding unit, with #1 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Weld testing equipment (weld test machine, or vise)

Materials Needed:

1. Six each - 16 ga. x 2 x 3 HRMS plate (Steel of different dimensions may be substituted.)
* 2. Two each - 1/16" x 36" No. 7 welding rod (Bend one end of each rod into a "shepherd's crook." Do not cut the rods.)

Procedure:

Step 1: Prepare the metal to be welded by cleaning it with a wire brush.

Step 2: Set up the metal for welding.

Step 3: Set up the equipment for welding, light the torch, and adjust to a neutral flame. (Refer to Shop Exercise #1 for a review of these procedures.) Refer to HO-1 for the proper oxygen and acetylene pressures for the tip size used.

Step 4: Perform the corner weld without rod.

a) Space the two pieces evenly, place the first tack weld at the center of the area to be welded, then tack the end where the weld will finish. Hold the torch at a 45-degree angle to the joint and play the flame on the two edges. (Refer to Figures 1, 2, and 3.)

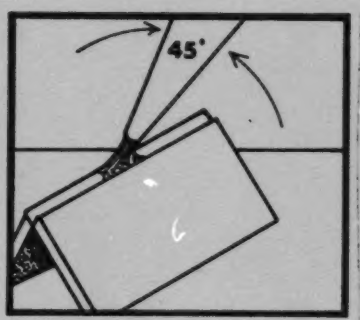


Figure 1

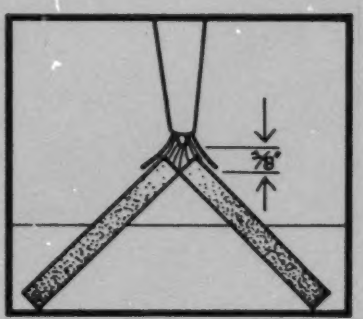


Figure 2

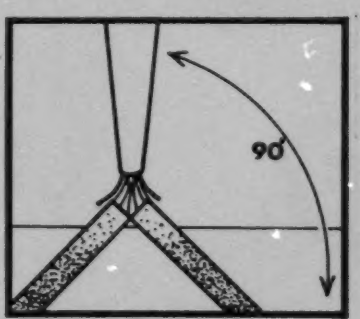


Figure 3

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

When the two pieces are fused together, move to the other end to start welding.

b) Point the flame at a point just inside the right edge of the joint. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the end of the work. (Refer to Figure 4.)

c) Hold this position until a puddle of molten metal is formed.

d) Move the puddle forward to the end of the weld.

e) Lay this weld aside and proceed to the next weld.

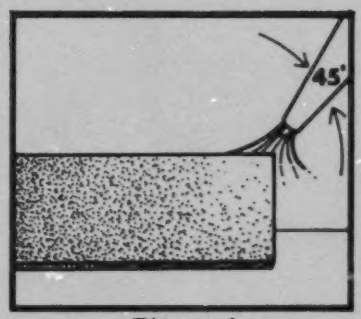


Figure 4

Step 5: Weld a corner weld with rod.

a) Space the two pieces evenly, place the first tack weld at the center of the are to be welded, then tack the end where the weld will finish. Hold the torch at a 45-degree angle to the joint and play the flame on the two edges. When the two pieces are fused together, move to the other end to start welding. (Refer to Figure 5.)

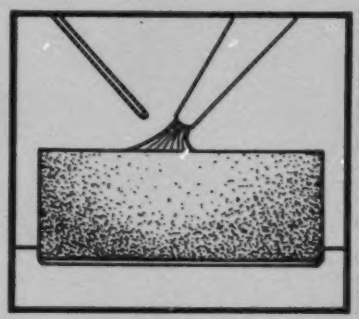


Figure 5

b) Point the flame at a point just inside the right edge of the joint. Hold the torch at a 45-degree angle to the work, with the end of the inner cone approximately 1/8-inch from the end of the work.

c) Hold this position until a puddle of molten metal is formed.

d) While waiting for the puddle to form, heat the end of the welding rod by holding it in the outer envelope of the flame. Heat until the tip of the rod is white-hot. (Refer to Figure 6.)

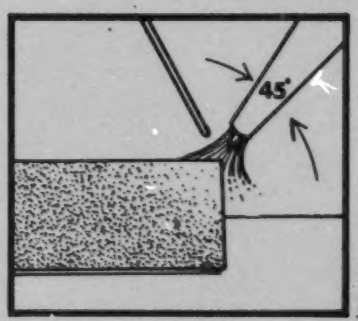


Figure 6

e) Move the puddle forward along the joint to the end of the weld, dipping the end of the rod in and out of the puddle. Keep the end of the rod hot by keeping it in the outer envelope of flame when the rod is not in contact with the puddle. (Refer to Figure 7.)

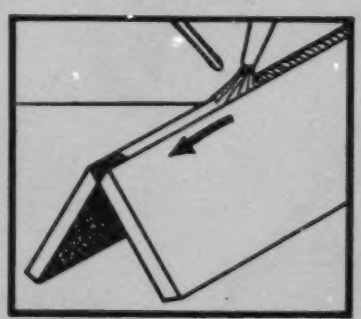


Figure 7

Step 6: Shut off the torch and put up the equipment. (Refer to Shop Exercise #1 for a review of these procedures.)

Step 7: Cool each weld; then break each one to check the penetration and metal fusion. (Do not try to break any weld hotter than room temperature.)

a) Destruction testing with a hydraulic press.
   1) Place welded side up so that the press pushes down against it, trying to flatten the "V".
   2) When the welded joint breaks, examine the weld. If the weld was properly fused to both pieces, the base metal should tear. The weld itself should not break.

b) Destruction testing using a vise.
   1) Place weld in the vise so that as the vise is tightened it flattens the "V".
   2) If the weld breaks, inspection of the pieces should reveal that the base metal has broken, not the weld.

Step 8: Reuse the practice metal. You should be able to get four separate welds for each two pieces of practice metal. (When you have a weld with satisfactory surface appearance and penetration, allow the weld to air-cool for greater strength. Hand in to the instructor when requested.)

UNIT- OXY-ACETYLENE WELDING

Lesson 3: How do I braze metal?

Objective: At the end of this lesson, the student will be able to braze metal using the oxy-acetylene torch.

Study Questions:

1. **What is brazing?**
2. **What are the advantages and disadvantages of brazing?**
3. **What is a flux and how is it used?**
4. **What is the procedure to follow when brazing?**
5. **How can I tell if the brazing has been done properly?**

References:

1. Oxy-acetylene Brazing, Cutting and Welding, Instructor's Manual, Smith Equipment, Lessons III-VI.
2. Welding Skills and Practices, Giachino, Weeks, and Brune, Chapter 28.
3. Modern Agricultural Mechanics, Wakeman, Chapter 8.
4. Shopwork on the Farm, 2nd Edition, Jones, Chapter 17.
5. Transparency Masters
   a. TM-6: Differences Between Brazing and Fusion Welding
   b. TM-7: Commonly Used Fluxes for Brazing
6. Handout
   a. HO-2: Commonly Used Fluxes for Brazing
7. Shop Demonstrations
   a. #4: Running a Bead with Bronze Rod
   b. #5: Brazing a Corner Weld in Mild Steel
8. Shop Exercises
   a. #4: Running a Bead with Bronze Rod
   b. #5: Brazing a Corner Weld in Mild Steel

UNIT - OXY-ACETYLENE WELDING

Lesson 3: How do I braze metal?

TEACHING PROCEDURES

A. Review of the previous lesson.

B. Motivation: Pass several bronze rods around the classroom. Ask the students to identify the type of metal in the rods. What are bronze rods used for?

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students what brazing is. Show TM-6 to the students, then discuss how brazing is different from fusion welding.

   What is brazing?

   1) Brazing is a metallic bonding of pieces of metal.
   2) How brazing is different from fusion welding. (Refer to TM-6.)
      a) Fusion welding heats the metal beyond the melting point so that the pieces melt together (fuse) to become one.
      b) Brazing uses a flux to clean the area and prevent oxides from forming and uses bronze (60% copper and 40% zinc) to fill the pores of the metal, holding pieces together.

2. Ask the students what the advantages and disadvantages of the brazing process are.

   What are the advantages and disadvantages of brazing?

   1) Advantages of brazing.
      a) Brazing can be used to join dissimilar metals (steel to cast iron, for example).
      b) Braze welds are easily machined, so brazing is ideal for building up worn parts.
      c) There is less danger of destroying the mechanical properties of the base metal because lower temperatures are required for brazing than for fusion.
   2) Disadvantages of brazing.
      a) Brazing cannot be used in applications where the resulting joint will operate in temperatures in excess of 500° F.

3. Ask the students what a flux is and the purpose of using flux. Hand out HO-2 to the students. Show TM-7 to the students. Ask the students why one flux will not work for all metals.

What is a flux and how is it used?

1) Flux removes any oxides present on the surface of the metal to allow a uniform flow of the brazing metal.
2) No one flux works for all base metals - different fluxes are made for each kind of base metal.

4. Ask the students what procedures to follow while brazing. List suggestions on the bulletin board; then follow the suggestions, using an oxy-acetylene unit (leaving it unlit).

What is the procedure to follow when brazing?

1) Prepare the metal to be brazed by removing any rust, scale, oil, etc. (Use of pickled steel will eliminate this step.)
2) Space the metal pieces to be brazed. For proper bonding, the spacing should be .002 to .010 inch.
3) Set up the equipment and light the torch, adjusting to a slightly oxidizing flame.
4) Heat a spot at the center of the joint in preparation for tacking.
5) Heat the end of the bronze rod until it is hot enough to melt the flux by holding it in the outer envelope of flame.
6) Dip the hot end of the bronze rod in the flux.
7) Continue heating the base metal until it is cherry red; then tack the pieces together by adding a small amount of bronze. Repeat tacking procedure at the end where the weld will finish.
8) Move to the right end of the joint, and heat the base metal until it is cherry red.
9) If heavy gauge metal is being brazed, the edges should be bevelled and the surfaces properly tinned. To tin the surfaces, melt a small amount of bronze rod onto the surface and allow a thin film to spread along the entire seam. After the entire joint is tinned, deposit a filler bead of bronze in the joint.
10) Carry a puddle of bronze along the joint. Keep dipping the rod in the flux as the weld progresses.
11) Shut off the torch and put up the equipment.
12) Cool and break the practice welds. If proper bonding has occurred, the bronze will pull part of the base metal away as the weld breaks.

5. Ask the students how to tell if the brazing has been done properly.

How can I tell if the brazing has been done properly?

1) If the bronze does not flow, but balls up instead, the base metal is underheated.
2) If the bronze gives off white fumes, the base metal is overheated.
3) If the bronze has a dull film on it, not enough flux was used.
4) If the bronze flows, but does not flow smoothly, the base metal was not properly cleaned.
5) If the rod melts rapidly and gives off fumes, the diameter of the bronze rod is too small.

F. Other Activities

Shop Demonstration
- #4: Running a Bead with Bronze Rod
- #5: Brazing Mild Steel

Shop Exercise
- #4: Running a Bead with Bronze Rod
- #5: Brazing Mild Steel

G. Summary

When brazing, a student should:

1. Make sure the base metal has been properly cleaned.
2. Adjust the torch to a slightly oxidizing flame.
3. Use the appropriate flux for the base metal being brazed.
4. Heat the base metal to a cherry red color to allow easy, uniform flow of bronze without overheating the bronze.

H. Answers to Evaluation

1. F
2. F
3. T
4. T
5. T
6. T
7. F
8. F
9. T
10. T

Lesson 3: How do I braze metal?

EVALUATION

The following statements are either true or false. Circle a T if the statement is true; circle an F if the statement is false.

T F 1. If the bronze balls up instead of flowing evenly, this is an indication that the base metal has been overheated.

T F 2. In the brazing process, the steel being brazed melts and alloys itself with the bronze.

T F 3. Because bronze is easily machined, brazing is an ideal process for building up worn sections of moving parts.

T F 4. The proper color for the base metal during brazing is cherry red.

T F 5. Brazing can be used successfully to bond steel and cast iron together.

T F 6. A dull film on a braze weld indicates not enough flux was used.

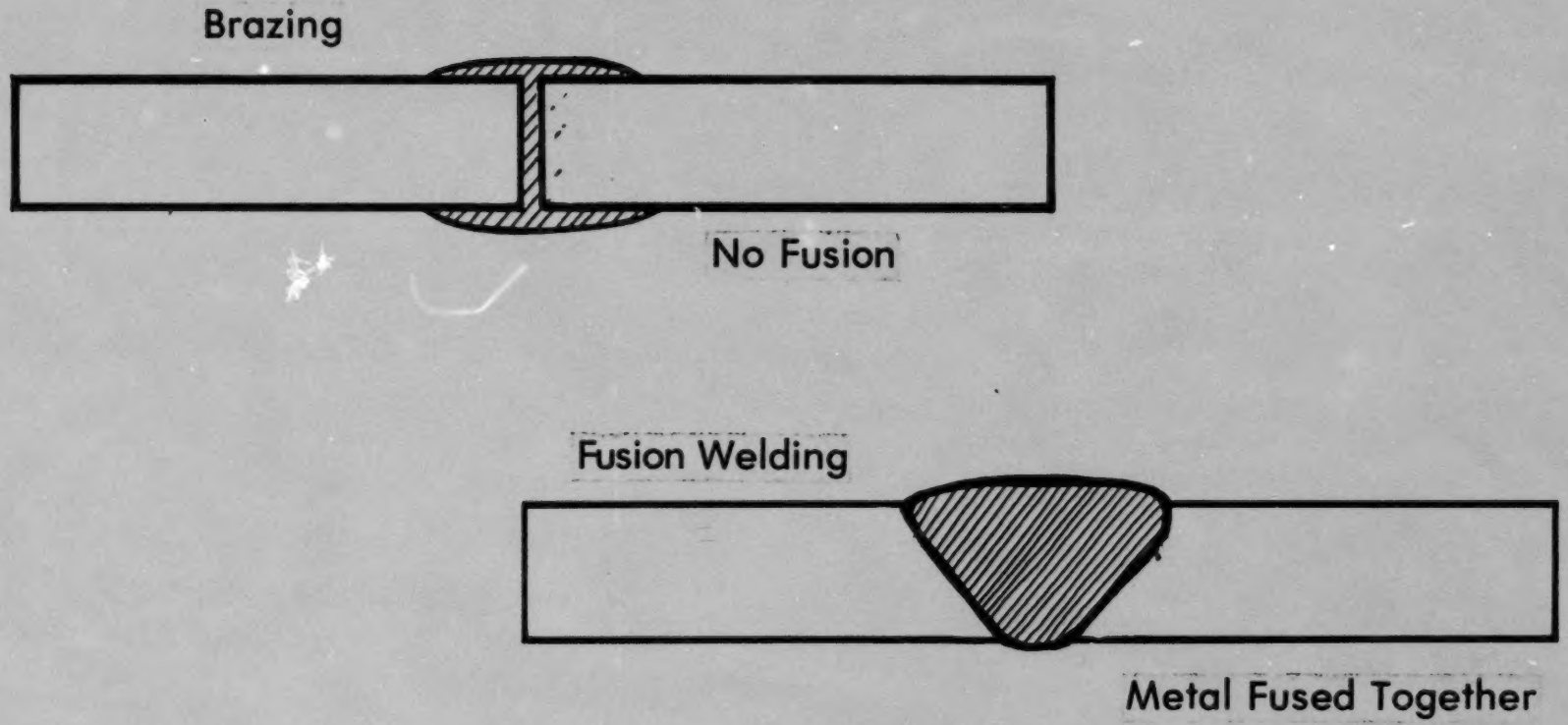
T F 7. A flux suitable for brazing aluminum would also be suitable for brazing steel.

T F 8. If the bronze gives off white fumes while brazing, this indicates that the base metal is not hot enough.

T F 9. Because bronze loses its strength at high temperatures, brazing should not be done if the working temperatures of the application exceed 500° F.

T F 10. Flux is used to remove any oxides on the surface of the metal, which allows the bronze to flow evenly.

Differences Between Brazing and Fusion Welding



Commonly Used Fluxes for Brazing

Base Metal Being Brazed	Filler Metals Recommended	Effective Temperature Range, °F	Ingredients in the Flux	Form	Method of Use
Aluminum	Brazing filler metal + Aluminum + Silicon	700-1190	Chlorides Fluorides	Powder	1, 2, 3, 4
Steel, Brass	All brazing filler metals except Brazing filler metal + Aluminum + Silicon and Brazing filler metal + Magnesium	700-2000	Boric acid Borates Fluorides Fluoborates Wetting Agent	Paste, Powder, or Liquid	1, 2, 3
	Same as above block plus Brazing filler metal + Silver #1-7	1000-2200	Borax Boric acid Borates Wetting agent	Paste, Powder, or Liquid	1, 2, 3

Methods of Use:

1. Dry powder sprinkled on the joint region.
2. Heated metal filler rod is dipped into powder or paste.
3. Flux is mixed with alcohol, water, monochlorobenzene, etc. to form a paste or slurry.
4. Flux is used molten in a bath.

Adapted from **Machinery's Handbook**, 17th Edition.

UNIT - OXY-ACETYLENE WELDING

SHOP DEMONSTRATION #4: Running a Bead with Bronze Rod

Objective: At the end of this demonstration, the student should be able to begin the shop exercise in running a bead with bronze rod.

Tools Needed:

1. Oxy-acetylene welding unit, with #1 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush

Materials Needed:

1. One each - 16 ga. x 2" x 3" HRMS plate (Steel of different dimension may be substituted.)
* 2. One each - 1/16" x 36" bronze rod (Bend one end of the rod into a "shepherd's crook." Do not cut the rod.)
3. Flux suitable for brazing mild steel

Procedure:

Step 1: Demonstrate proper metal preparation using a wire brush and lightly grinding the surface. (Use of pickled steel will eliminate this step.)

Step 2: Demonstrate how to lay off lines to follow while brazing.

Step 3: Demonstrate how to safely set up the equipment for brazing and how to light the torch. (See Shop Demonstration #1 for a review of these procedures.) Refer to TM-1 for proper oxygen and acetylene working pressures.

Step 4: Demonstrate how to adjust the torch to a <u>slightly</u> oxidizing flame.

Step 5: Demonstrate how students will complete the required exercise in running a bead with bronze rod.

a) Point the torch at a point just inside the right edge of the practice metal.
b) While waiting for the practice metal to heat, hold the end of the bronze rod in the outer envelope of flame until the rod is hot enough to melt the flux.
c) Dip the hot end of the brazing rod in the flux. (This will melt the flux and a small amount will stick to the rod.)

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

d) Continue heating until the base metal is cherry red.
e) Using the same dipping techniques used in fusion welding with rod, carry a bead from one side of the base metal to the other. Follow one of the scribed lines laid out in Step 2.

Step 6: Demonstrate how to safely shut off the torch and put up the equipment. (Refer to Shop Demonstration #1 for a review of these procedures.)

Step 7: Demonstrate how to safely cool the brazed metal before proceeding to the next bead.

UNIT - OXY-ACETYLENE WELDING

SHOP EXERCISE #4: Running a Bead with Bronze Rod

Objective: At the end of this exercise, the student should be able to run a bead with bronze rod.

Tools Needed:

1. Oxy-acetylene welding unit, with #1 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush

Materials Neded:

1. One each - 16 ga. x 2" x 3" HRMS plate (Steel of different dimensions may be substituted.)
* 2. One each - 1/16" x 36" bronze rod (Bend one end of the rod into a "shepherd's crook." Do not cut the rod.)
3. Flux suitable for brazing mild steel

Procedure:

Step 1: Prepare the metal for brazing by removing any rust, scale, etc., with a wire brush and lightly grinding the surface. (Use of pickled steel will eliminate this step.)

Step 2: Using scratch awl or center punch, lay off five lines 1/2-inch apart on the surface of the base metal to use as a guide while running beads.

Step 3: Set up the equipment; then light the torch. (See Shop Exercise #1 for a review of these procedures.) Refer to HO-1 for the proper oxygen and acetylene working pressures for the tip size used.

Step 4: Adjust the flame to a slightly oxidizing flame.

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

Step 5: Run a bead with bronze rod.

a) Point the torch at a point just inside the right edge of the practice metal. (Refer to Figures 1 and 2.)

b) While waiting for the practice metal to heat, hold the end of the bronze rod in the outer envelope of flame until the rod is hot enough to melt the flux. (Refer to Figure 3.)

c) Dip the hot end of the brazing rod in the flux. (This will melt the flux and a small amount will stick to the rod.)

d) Continue heating until the base metal is cherry red.

e) Using the same dipping technique used in fusion welding with rod, carry a bead from one side of the base metal to the other. (Refer to Figure 4.) Follow one of the scribed lines laid out in Step 2. (Refer to Figure 5.)

Step 6: Shut off the torch and put up the equipment. (See Shop Exercise #1 for a review of these procedures.)

Step 7: Cool the metal between beads to remove built-up heat. This way, each bead will begin with the base metal approximately the same temperature.

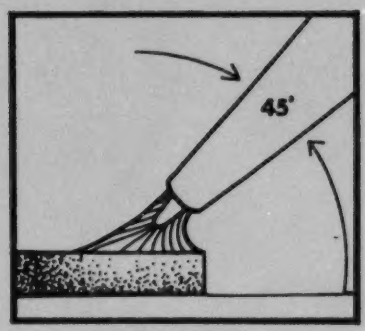


Figure 1

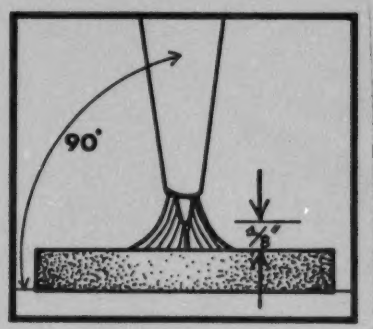


Figure 2

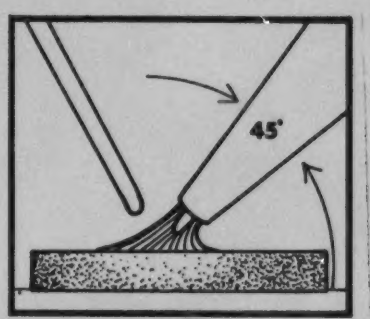


Figure 3

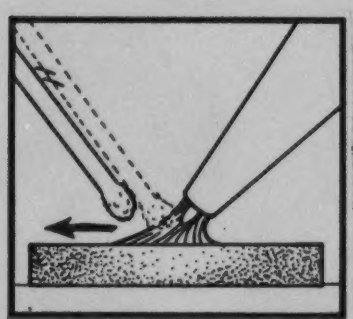


Figure 4

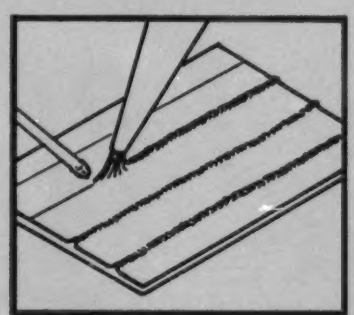


Figure 5

UNIT - OXY-ACETYLENE WELDING

SHOP DEMONSTRATION #5: Brazing a Corner Weld in Mild Steel

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise in brazing a corner weld in mild steel.

Tools Needed:

1. Oxy-acetylene welding unit, with #1 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Weld testing equipment (weld test machine or vise)

Materials Neded:

1. Two each - 16 ga. x 2" x 3" HRMS plate (Steel of different dimensions may be substituted.)
* 2. Two each - 1/16" x 36" bronze rod (Bend one end of each rod into a "shepherd's crook." Do not cut the rods.)
3. Flux suitable for brazing mild steel

Procedure:

Step 1: Demonstrate proper metal preparation for brazing using a wire brush and lightly grinding the surface. (Use of pickled steel will eliminate this step.)

Step 2: Demonstrate how to space the metal to be brazed to allow for proper bonding. (Space each piece .002 to .010 inch apart.)

Step 3: Demonstrate how to safely set up the equipment for brazing and how to light the torch. (See Shop Demonstration # 1 for a review of these procedures.) Refer to TM-1 for proper oxygen and acetylene working pressures.

Step 4: Demonstrate how to adjust the torch to a slightly oxidizing flame.

Step 5: Demonstrate how students will complete the required exercise in brazing.

a) Heat a spot at the center of the joint in preparation for tacking the pieces together.
b) At the same time, hold the end of the brazing rod in the outer envelope of flame until the rod is hot enough to melt the flux.
c) Dip the hot end of the brazing rod in the flux. (This will melt the flux and a small amount will stick to the rod.)

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted. In addition, the procedures for brazing will vary as the steel gets thicker.**

d) Continue heating until the base metal is cherry red; then tack the pieces together by adding a small amount of bronze. Repeat tacking procedure at the end where the weld will finish. (Use the same dipping technique used in fusion welding with a rod.)

e) Move to the right end of the joint and heat both pieces until the edges are cherry red.

f) Using the same dipping technique used in fusion welding, carry a puddle of bronze along the joint, bonding the pieces together. Make sure that a thin coating of flux is maintained on the rod as the bronze weld progresses.

Step 6: Demonstrate how to safely shut off the torch and put up the equipment. (Refer to Shop Demonstration #1 for a review of these procedures.)

Step 7: Demonstrate how to safely cool the brazed joint and how to test for proper bonding.

a) Cool the joint. (Do not attempt to break a brazed joint that is above room temperature.)

b) Break the weld and examine the weld for proper bonding. (Place weld in the test equipment so that the "V" is flattened and the weld is broken.)

Step 8: Demonstrate how to reuse the practice metal to make maximum use of practice metal.

UNIT - OXY-ACETYLENE WELDING

SHOP EXERCISE #5: Brazing a Corner Weld in Mild Steel

Objective: At the end of this exercise, the student should be able to braze a corner weld in mild steel.

Tools Needed:

1. Oxy-acetylene welding unit, with #1 tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Wire brush
7. Weld testing equipment (weld test machine or vise)

Materials Neded:

1. Four each - 16 ga. x 2" x 3" HRMS plate (Steel of different dimensions may be substituted.)
* 2. Two each - 1/16" x 36" bronze rod (Bend one end of each rod into a "shepherd's crook." Do not cut the rod.)
3. Flux suitable for brazing mild steel

Procedure:

Step 1: Prepare the metal for brazing by removing any rust, scale, etc., with a wire brush and lightly grinding the surface. (Use of pickled steel will eliminate this step.)

Step 2: Space the metal in preparation for tacking and brazing. Space each piece .002 to .010 inch apart.

Step 3: Set up the equipment; then light the torch. (See Shop Exercise #1 for a review of the procedures for setting up the equipment.) Refer to HO-1 for the proper oxygen and acetylene working pressures for the tip size used.

Step 4: Adjust the torch to a <u>slightly</u> oxidizing flame.

*** An additional rod or rods of different diameter may be needed if steel of different dimensions is substituted.**

Step 5: Braze the assigned joint.

a) Heat a spot at the center of the joint in preparation for tacking the pieces together. (Refer to Figures 1 and 2.)
b) At the same time, hold the end of the brazing rod in the outer envelope of flame until the rod is hot enough to melt the flux. (Refer to Figure 3.)
c) Dip the hot end of the brazing rod in the flux. (This will melt the flux and a small amount will stick to the rod.)
d) Continue heating until the base metal is cherry red; then tack the pieces together by adding a small amount of bronze. (Refer to Figure 4.) Repeat tacking procedure at the end where the weld will finish. (Use the same dipping technique used in fusion welding with a rod.)
e) Move to the right end of the joint and heat both pieces until the edges are cherry red. (Refer to Figure 5.)
f) Using the same dipping technique used in fusion welding, carry a puddle of bronze along the joint, bonding the pieces together. Make sure that a thin coating of flux is maintained on the rod as the bronze weld progresses. (Refer to Figure 6.)

Step 6: Shut off the torch and put up the equipment. (See Shop Exercise #1 for a review of these procedures.)

Step 7: Cool the joint; then test the bonding of the braze by destruction testing, using a weld test machine or a vise. (Omit this step for the weld to be handed in. Allow that weld to air-cool to room temperature for maximum strength.)

Step 8: Reuse the practice metal. You should be able to use each piece for four different brazings.

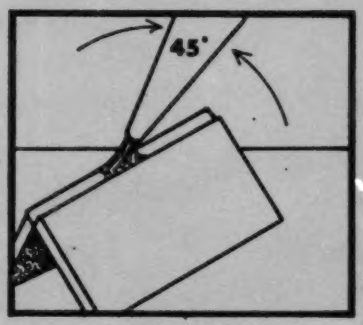


Figure 1

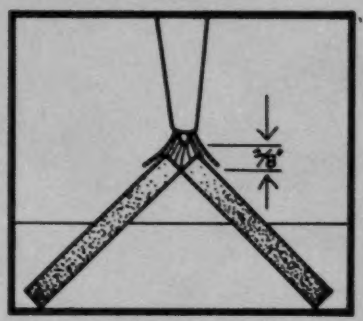


Figure 2

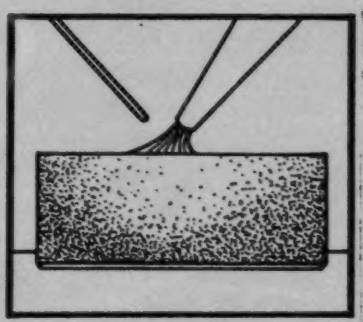


Figure 3

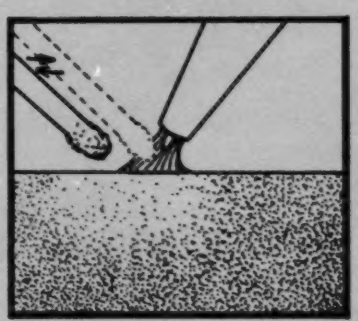


Figure 4

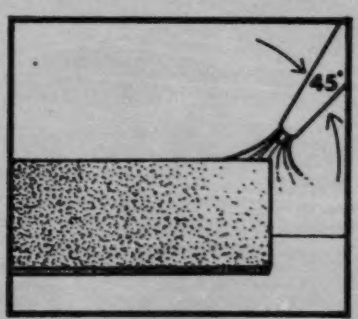


Figure 5

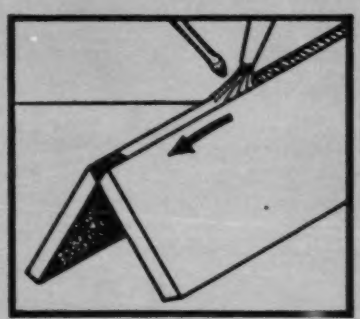


Figure 6

UNIT - OXY-ACETYLENE WELDING

Lesson 4: How do I heat metal using the oxy-acetylene unit?

Objective: At the end of this lesson, the student will be able to heat metal with the oxy-acetylene unit in preparation for bending.

Study Questions:

1. **How do I care for the rosebud heating tip?**
2. **How do I use the heating tip to help in removing nuts from rusty bolts?**
3. **How can I use the oxy-acetylene unit to heat flat or round stock for bending?**
4. **How do I make wrinkle bends in pipe using the oxy-acetylene unit?**

References:

1. Transparency Masters
   a. TM-8: Heat a Narrow Band to Make a Sharp Bend in Flat or Round Stock
   b. TM-9: Wrinkle Combinations for Short and Long Radius Bends in 2 and 3 Inch Steel Pipe
   c. TM-10: Wrinkle Spacing for 2 and 3 Inch Steel Pipe
   d. TM-11: Pipe Layout for Wrinkle Bending
   e. TM-12: Chalk Line Guides
2. Handout
   a. HO-3: Heating Metal with the Oxy-acetylene Unit
3. Shop Demonstration
   a. #6: Heating Metal with the Oxy-acetylene Unit

UNIT - OXY-ACETYLENE WELDING

Lesson 4: How do I heat metal using the oxy-acetylene unit?

TEACHING PROCEDURES

A. Review of the previous lesson.

B. Motivation: Pass around to the class examples of pipe which has been wrinkle bent. Ask the students when such a technique would be required.

C. Assignment: Have the students read HO-3.

D. Supervised Study

E. Discussion

1. Ask the students how to care for the rosebud heating tip.

How do I care for the rosebud heating tip?

1) Keep the tip clean.
2) Use a tip wrench of the correct size when changing tips.
3) Do not insert a tip while the torch is hot.
4) Check the "O" rings for damage or leakage before installing the tip.

2. Ask the students how to use the heating tip to help in removing rusted nuts.

How do I use the heating tip to help in removing nuts from rusty bolts?

1) Clear flammable materials from the area of the rusted nut.
2) Use a neutral flame and heat the nut until it is cherry red.
3) Allow the nut to cool before removing.

3. Show TM-8 to the students. Ask the students how they can use the oxy-acetylene unit to heat flat or round stock for bending.

How can I use the oxy-acetylene unit to heat flat or round stock for bending?

1) Clamp the metal securely in a bench vise at a point just below the bend.
2) The key to making sharp bends is to heat only a narrow band. (Refer to TM-8.)
3) The metal is ready to bend when it reaches a cherry red color.

4. Show TM-9, TM-10, and TM-11 to the students. Ask the students how to make a wrinkle bend in pipe. Show TM-12 to the students. Ask the students how to lay out the chalk line guides on the floor.

How do I make wrinkle bends in pipe using the oxy-acetylene unit?

1) Determine the number of wrinkles and the number of degrees per wrinkle. (Refer to TM-9.)

2) Determine the spacing between wrinkles. (Refer to TM-10.)
3) Lay out the bend on the pipe. (Refer to TM-11.)
4) Heat one wrinkle at a time, heating a narrow band nearly around the pipe.
5) When the heated band reaches a light yellow color, bend with a steady force until the desired angle is reached.
6) Allow each bend to cool to a black heat stage before moving to the next bend.
7) Chalking lines on the floor at the appropriate angles will help to gauge when to stop bending. (Refer to TM-12.)

F. Other Activities

Shop Demonstration
#6 - Heating Metal with the Oxy-acetylene Unit

G. Summary

When heating metal using the oxy-acetylene unit, the student should:

1. Take proper care of the heating tip.
2. Heat rusted nuts to a cherry red color, then allow them to cool before removing.
3. Heat flat and round stock to a cherry red color before bending.
4. Lay out the wrinkle bend, heat each wrinkle to a light yellow color before bending, and allow each bend to cool to a black heat stage before moving to the next bend.

H. Answers to Evaluation

1. T
2. T
3. T
4. T
5. F

Lesson 4: How do I heat metal using the oxy-acetylene unit?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. Flat stock is ready to bend when it reaches a cherry red color.

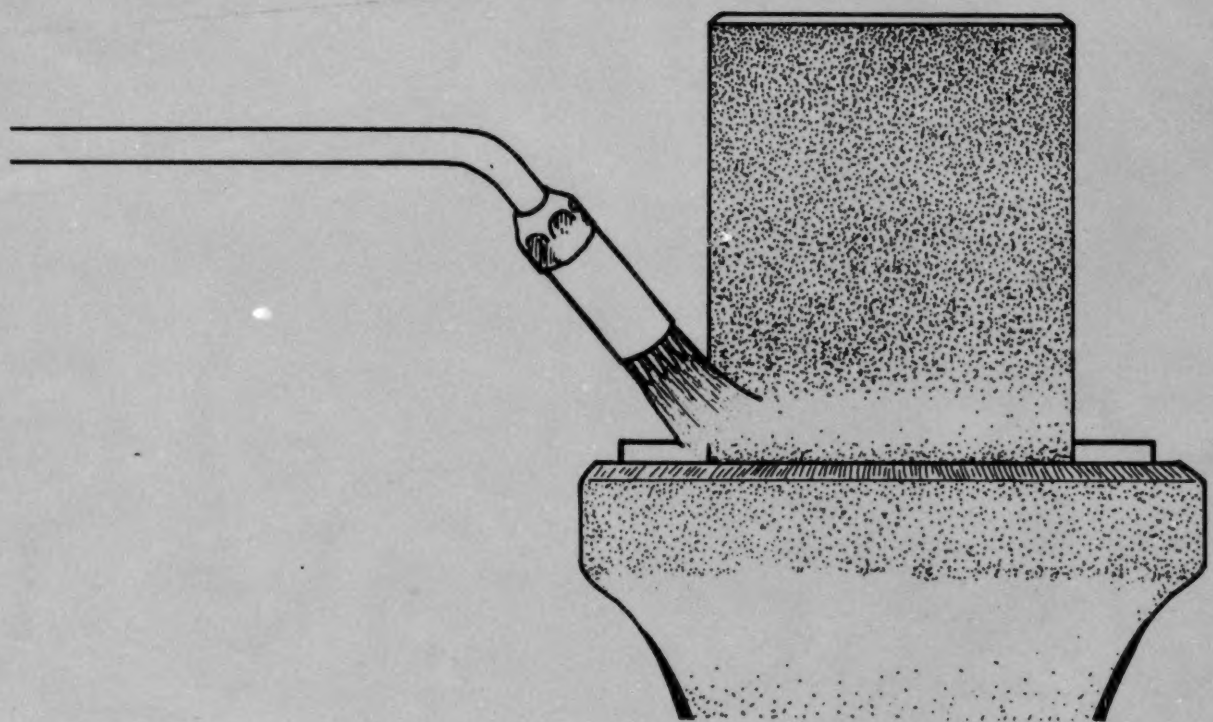
T F 2. Each wrinkle bend should be allowed to cool to a black heat stage before starting the next wrinkle.

T F 3. Heating a nut which has rusted to a bolt to a cherry red color will allow for easier removal after it has cooled.

T F 4. A wrinkle bend should be heated to a light yellow color before bending.

T F 5. To make a sharp bend in round stock, heat a wide area before bending.

Heat a Narrow Band to Make a Sharp Bend in Flat or Round Stock



Wrinkle Combinations for Short and Long Radius Bends in 2 and 3 Inch Steel Pipe

Pipe Size	Total Angle of Bend in Degrees Number of Wrinkles and Degrees per Wrinkle Bend to Make Up Total Bend						
	7½	15	22½	30	45	60	90
2-inch	1 @ 7½	1 @ 15 2 @ 7½	2 @ 11¼ 3 @ 7½	2 @ 15 3 @ 10 4 @ 7½	3 @ 15 4 @ 11¼ 5 @ 9 6 @ 7½	3 @ 20 4 @ 15 5 @ 12 6 @ 10 8 @ 7½	5 @ 18 6 @ 15 8 @ 11¼ 9 @ 10 10 @ 9 12 @ 7½
3-inch	1 @ 7½	1 @ 15 2 @ 7½	2 @ 11¼ 3 @ 7½	2 @ 15 3 @ 10 4 @ 7½	3 @ 15 4 @ 11¼ 5 @ 9 6 @ 7½	4 @ 15 5 @ 12 6 @ 10 8 @ 7½	5 @ 18 6 @ 15 8 @ 11¼ 9 @ 10 10 @ 9 12 @ 7½

from **Pipe and Tube Bending** by Paul B. Schubert

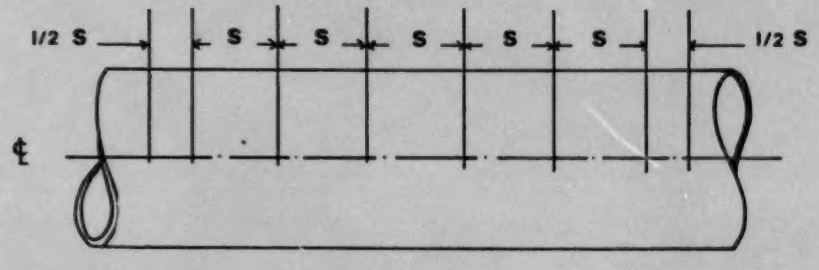
TM-9

Wrinkle Spacing for 2 and 3 Inch Steel Pipe

Degrees Per Wrinkle	Wrinkle Spacing 'S' in Inches Before Bending				
	1 ½	1 ¾	2	2 ¼	2 ½
20					
19					
18					
17					
16					
15					
14					
13					
12					
11					
10	2"	3"			
9					

2 in. Std. Pipe

3 in. Std. Pipe



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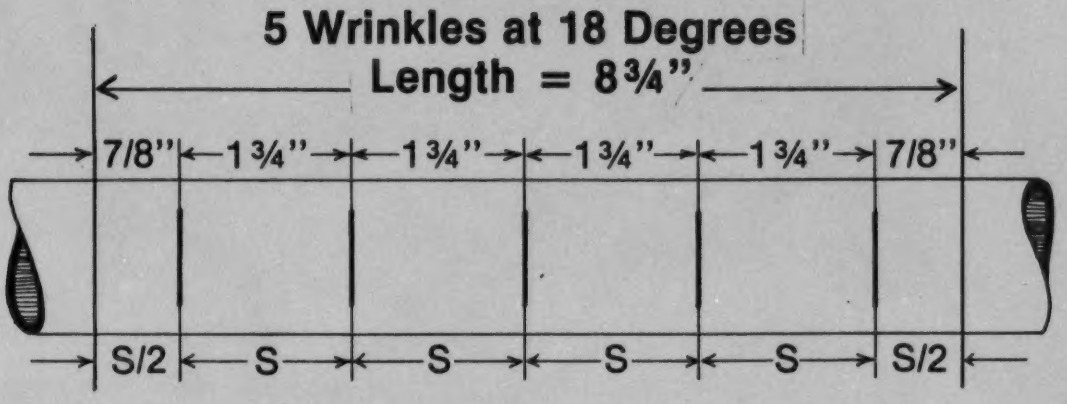
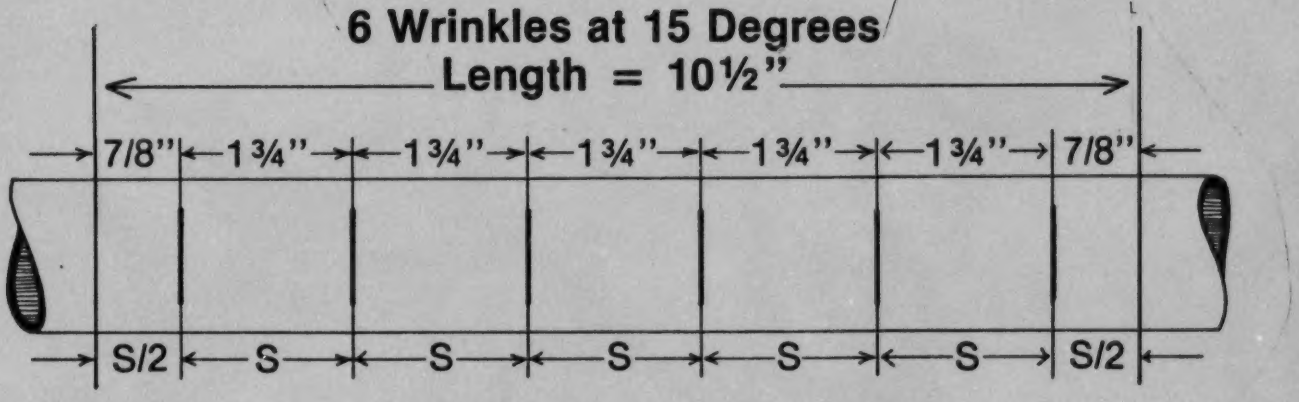
Pipe Layout for Wrinkle Bending





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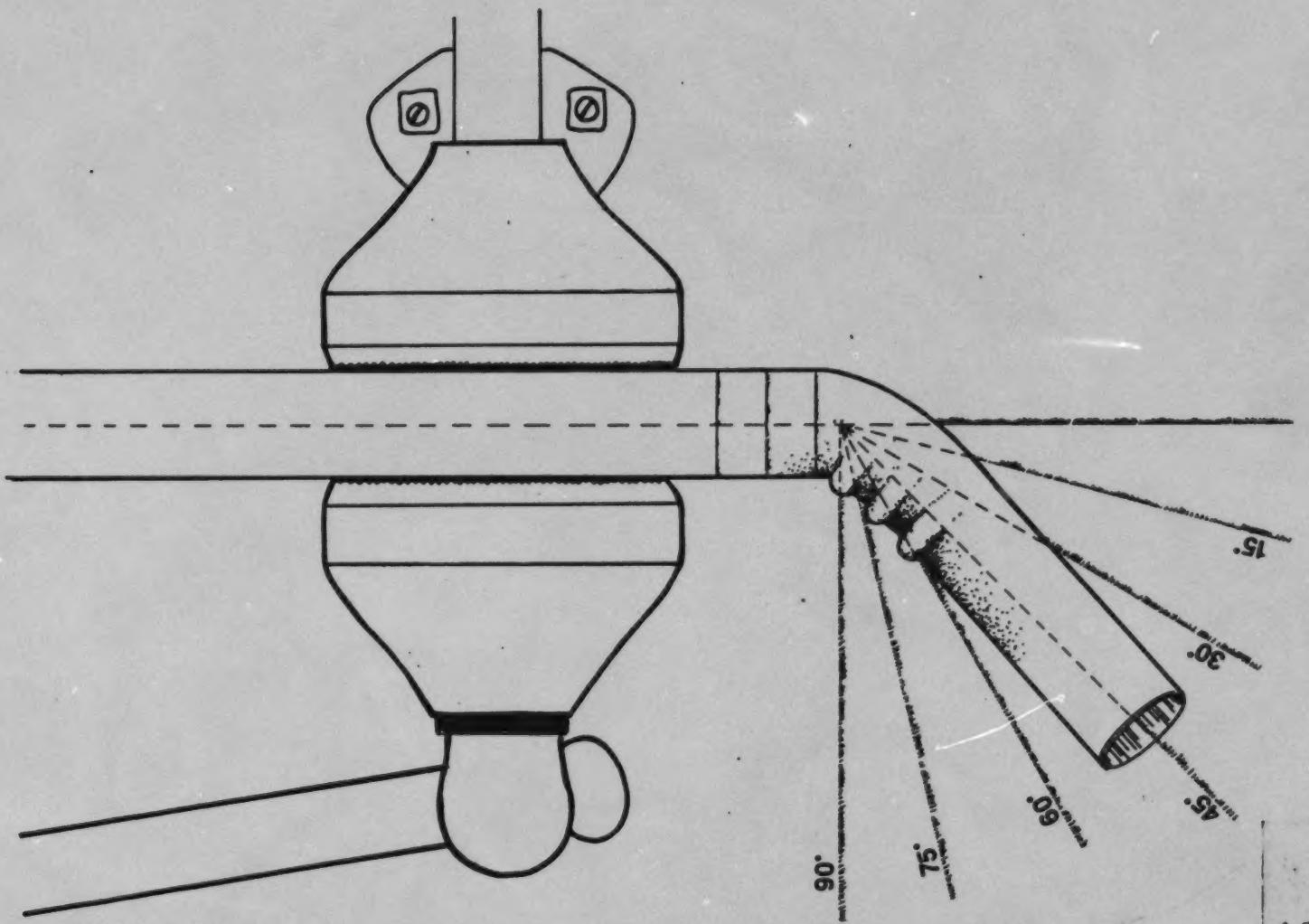
Chalk Line Guides



HEATING METAL WITH THE OXY-ACETYLENE UNIT

There will be times in the shop when you will need the heat the oxy-acetylene flame can provide. Heating nuts that are rusted to bolts for easier removal, heating flat and round stock for bending, and wrinkle bending pipe are all examples of uses of this heat that you will study in this lesson.

This heat can be supplied in three ways - by using a large welding tip, using the cutting torch (without depressing the cutting oxygen lever), or by using a tip made specially for heating (sometimes called a "rosebud" tip). Which one is the correct choice for a given application will depend largely on the area to be heated and how rapidly the heating is to be done. The large welding tip would be appropriate for smaller jobs. The cutting torch would produce more heat than the large welding tip. The rosebud tip would be appropriate for the largest heating jobs. The rosebud tip also uses the most acetylene and oxygen, so it is also more economical to use the other sources for smaller jobs. It is also important to remember not to remove more than 1/7 of the contents of the acetylene cylinder per hour. This may be a concern when using the rosebud tip.

Care of the Rosebud Heating Tip

The rosebud heating tip will give years of good service if it is taken care of properly. These procedures should help:

1. Keep the tip clean. If the openings of the tip appear dirty, use a tip cleaner of the correct size to clean out the accumulated carbon.

2. Use a tip wrench when changing tips. Using pliers will ruin the nut on the tip very quickly.

3. Do not insert a tip while the torch is hot. Tightening the tip nut while the tip is room temperature and the torch is hot will cause the nut to "freeze" to the threads.

4. Check the "O" rings before installing the tip. If the "O" rings are in good condition, they will prevent leakage of gases at the connection.

Removing Nuts from Rusty Bolts

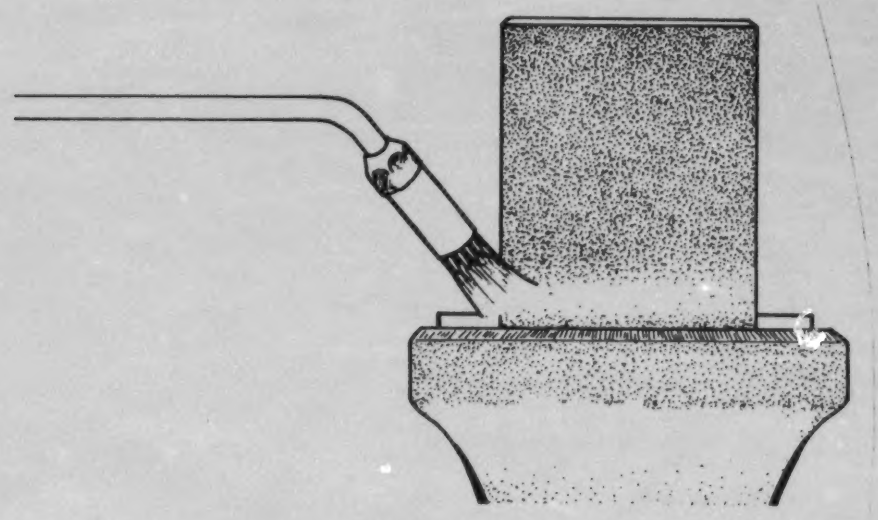
In farm machinery repair, it is common that nuts which need to be removed have rusted to the bolts. These can be removed easily through the use of the oxy-acetylene heating tip.

Clear any flammable materials from the vicinity of the nut, then light the torch and adjust to a neutral flame. Play the flame on the nut until the entire nut reaches a cherry red color. Allow the nut to cool. After cooling, the nut should be easy to turn with a wrench.

The nut expands when heated. Though it contracts as it cools, the nut does not return to its original size, but remains a little larger than before heating. This will allow the nut to turn more easily. In addition, the rust serves as insulation, keeping some of the heat from being transferred to the bolt.

Heating Flat or Round Stock for Bending

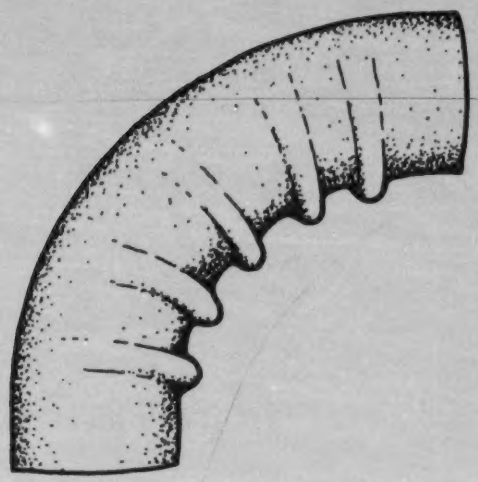
Flat stock and round stock may be bent easily to a desired angle if the metal is heated first with an oxy-acetylene heating tip. Clamp the metal securely in a bench vise at a point just below the bend. Heat the metal in a narrow band, centered on the point of the bend. The key to making a sharp bend is to heat only a narrow band, as shown in the following illustration.



When a narrow band of the flat or round stock reaches a cherry red color, the metal is ready to be bent. (If the metal begins to spark, the metal is burning and is too hot to bend. Stop heating and allow the metal to cool to cherry red before bending.) Shut off the torch and lay it aside. Bend the metal quickly to the desired angle before it cools. Heavier flats and thicker rounds may require repeated blows with a hammer to bend; lighter materials may be bent by grasping the free end with pliers or tongs and then bending.

Wrinkle Bending

The oxy-acetylene heating tip can also be used effectively in the wrinkle bending of pipe. Wrinkle bending involves heating a narrow band almost completely around a pipe, then bending with a steady force when the heated area reaches a light yellow color (1800°-2000° F.). Pipe steel has very little strength at this temperature, so the force applied to the pipe at this time causes a wrinkle to form. Using a series of wrinkle bends allows the pipe to be bent at a variety of angles, with no reduction in the flow inside the pipe. An example of a completed 90° bend is shown in the following illustration.



When laying out a wrinkle bend, three details are important - the number of wrinkles to be made, the number of degrees per wrinkle, and the spacing between each wrinkle. The following table shows various combinations of numbers of wrinkles and degrees per wrinkle for 2 and 3 inch pipe. (Pipe smaller than 2 inches can also be bent using wrinkle bending. The numbers of bends can be reduced, with more degrees per wrinkle, and less space between wrinkles.)

Pipe Size	Total Angle of Bend in Degrees						
	Number of Wrinkles and Degrees per Wrinkle Bend to Make Up Total Bend						
	7½	15	22½	30	45	60	90
2-inch	1 @ 7½	1 @ 15 2 @ 7½	2 @ 11¼ 3 @ 7½	2 @ 15 3 @ 10 4 @ 7½	3 @ 15 4 @ 11¼ 5 @ 9 6 @ 7½	3 @ 20 4 @ 15 5 @ 12 6 @ 10 8 @ 7½	5 @ 18 6 @ 15 8 @ 11¼ 9 @ 10 10 @ 9 12 @ 7½
3-inch	1 @ 7½	1 @ 15 2 @ 7½	2 @ 11¼ 3 @ 7½	2 @ 15 3 @ 10 4 @ 7½	3 @ 15 4 @ 11¼ 5 @ 9 6 @ 7½	4 @ 15 5 @ 12 6 @ 10 8 @ 7½	5 @ 18 6 @ 15 8 @ 11¼ 9 @ 10 10 @ 9 12 @ 7½

from **Pipe and Tube Bending** by Paul B. Schubert

Once you have determined the number of wrinkles and the number of degrees per wrinkle, refer to the following table to determine the spacing between wrinkles.

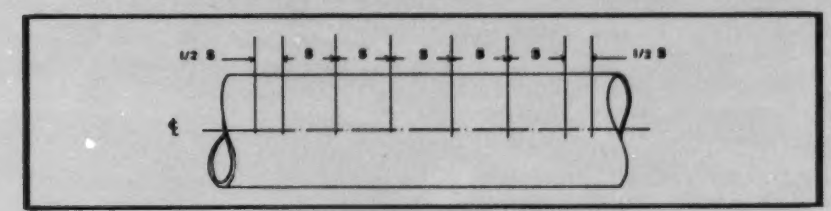
Degrees Per Wrinkle	Wrinkle Spacing 'S' In Inches Before Bending				
	1 ½	1 ¾	2	2 ¼	2 ½
20					
19					
18					
17					
16					
15					
14					
13					
12					
11					
10					
9					

2 in. Std. Pipe

3 in. Std. Pipe

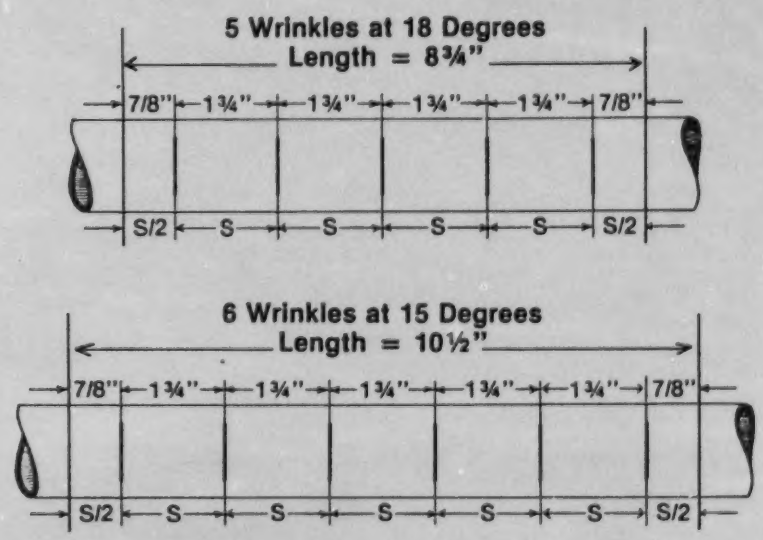
2"

3"



from **Pipe and Tube Bending** by Paul B. Schubert

After these details have been determined, the layout of the bend can be chalked onto the pipe. The illustration shows the layout of two wrinkle bends.



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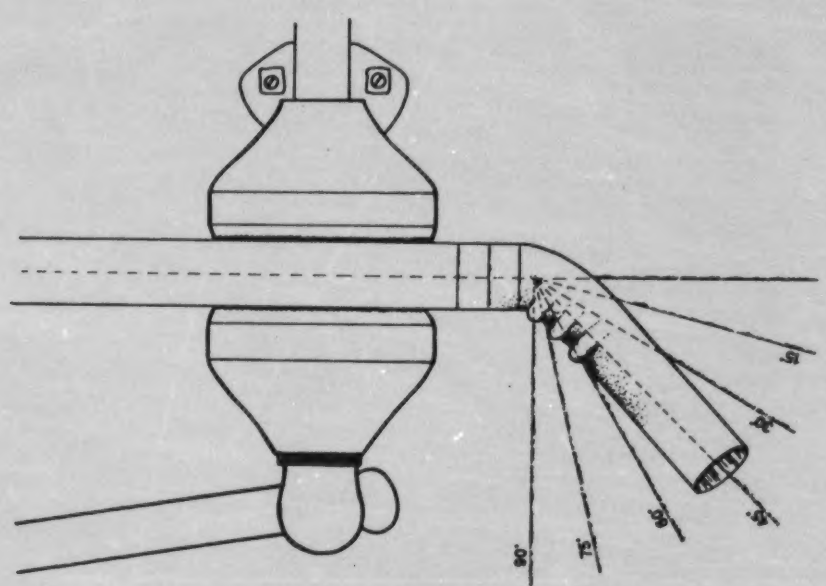
While heating the pipe for wrinkle bending, heat a narrow band (3/4-inch for 2 inch pipe; 1 inch for 3 inch pipe) almost completely around the circumference of the pipe. Bring this heated band to a light yellow color (2200° F.) before applying any bending force.

Continue heating the pipe while a steady bending force is applied. If the heat is not applied evenly or the heat band is not uniform around the pipe, the wrinkle will not form evenly. This will also cause the resulting bend to not be square with the layout.

Waiting until the proper moment to bend the pipe is very important. If the wrinkling is attempted at a temperature which is too low, stresses will be built up along the center line of the wrinkle, weakening the pipe. Wrinkling the pipe at a temperature which is too high also weakens the pipe, because the pipe will thin down too much as it stretches to make the wrinkle.

If more than one wrinkle is to be made, wait between each wrinkle until the pipe cools to a black heat stage (600°-700° F.). Pipe steel is at its maximum strength at this temperature, so that heating for the next wrinkle can begin without any malformation of the pipe.

When wrinkle bending pipe to a specific angle, it will be helpful to draw chalk lines on the floor to gauge the bend, as illustrated.



When laying out the chalk lines, use a plumb bob to lay out a line directly underneath the center of the pipe. (Use the center of the pipe, not the edges, because one side of the pipe stretches and the other compresses during the wrinkling process.)

Next, use the plumb bob to determine a point on that line directly beneath the center of the series of bends. From this point, use a protractor and chalk out the appropriate lines. In the example shown previously, these lines would be drawn at 15°, 30°, 45°, 60°, 75°, and 90° to the first line. For a 45° bend, with 5 bends at 9° each, the lines would be drawn at 9°, 18°, 27°, 36°, and 45°.

After the lines have been chalked on the floor, the wrinkling process may begin. When the pipe is hot enough to wrinkle bend, apply force until the pipe is parallel to the first angle line. Let that wrinkle cool to a black heat stage, then proceed to the next bend.

Summary

The heating tip for the oxy-acetylene unit is a useful tool for the shop. It can be used to heat rusted nuts for easier removal, to heat flat and round stock for bending, and to heat pipe for wrinkle bending.

The key to sharp bends in flat or round stock is to heat only a narrow band of the metal before bending. The stock should be heated to a cherry red color before bending.

There are three important factors in laying out a wrinkle bend - the number of wrinkles to be made, the number of degrees per wrinkle, and the spacing between each wrinkle. For each wrinkle, heat a narrow band until the steel is a light yellow color. Apply a steady bending force until the desired angle is reached. If more than one wrinkle is to be made, allow the heated area to cool to a black heat stage before heating the pipe for the next wrinkle. Chalking lines on the floor showing the degrees for each bend will help to make a more uniform finished product.

Credits

1. Working in Agricultural Mechanics, Shinn and Weston.

2. Pipe and Tube Bending, Schubert.

UNIT - OXY-ACETYLENE WELDING

SHOP DEMONSTRATION #6: Heating Metal with the Oxy-acetylene Unit

Objective: At the end of this demonstration, the student should be prepared to heat metal with the oxy-acetylene unit in project construction.

Tools Needed:

1. Oxy-acetylene unit, with #9 tip, cutting torch, and rosebud heating tip
2. Oxy-acetylene goggles
3. Leather gloves
4. Safety goggles
5. Pliers
6. Vise grips or tongs

Materials Needed:

1. One each - Nut rusted to a bolt
2. One each - 1/8" x 4" x 8" HRMS plate (Steel of different dimensions may be substituted.)
3. One each - 5/8" HRMS round stock
4. One each - 2" x 4' black pipe

Procedure:

Step 1: Demonstrate removing a nut from a rusty bolt. (Use the rosebud tip.)

a) Clamp the nut securely in a vise.
b) Using a neutral flame, heat the nut until it is cherry red.
c) Allow the nut to cool.
d) Remove the nut with a wrench.

Step 2: Demonstrate bending flat stock. (Use the largest welding tip available for heating.)

a) Clamp the stock securely in a vise at a point just below the bend.
b) Heat a narrow band to a cherry red color.
c) Grasp the stock firmly with pliers, vise grips, or tongs, then bend to a 90° angle.
d) Set aside to cool.

Step 3: Demonstrate bending round stock. (Use the rosebud tip for heating.)

a) Clamp the stock securely in a vise at a point just below the bend.
b) Applying heat to the outside of the stock, heat a narrow band to a cherry red color.
c) Grasp the stock firmly with pliers or tongs, then bend to a 90° angle.
d) Repeat the above steps, heating the inside of the stock to demonstrate how the heating of the stock affects the final appearance of the bend.

Step 4: Demonstrate how to wrinkle bend pipe. (Use the cutting torch for heating.)

a) Using a predetermined number of wrinkles, number of degrees per wrinkle, and spacing between wrinkles, chalk the layout of the bend onto the pipe.
b) Clamp the pipe securely in a vise.
c) Lay out chalk lines on the floor to guide the bend.
d) Heat a narrow band nearly around the pipe, starting with the wrinkle nearest the end of the pipe.
e) When the heated band reaches a light yellow color, bend with a steady force until the pipe is aligned with the first degree mark chalked on the floor. (To apply the necessary force to make the bend, it may be necessary to use a "cheater," that is, a pipe of smaller diameter than the pipe being bent, to obtain greater leverage.)
f) Allow the first wrinkle to cool to a black heat stage, then repeat steps d and e. (Bending two wrinkles should be adequate for demonstration purposes.)
g) Allow pipe to cool.

UNIT - POWER TOOLS

Lesson 1: How can I use power tools safely?

Objective: At the end of this lesson, the student will be able to use power tools safely.

Study Questions:

1. **What safety precautions should I follow when using power tools?**
2. **What are the shop rules to follow concerning the use of power tools?**

References:

1. Power Tool Safety and Operation Instructor's Packet, Hoerner and Bettis.
2. Modern Agricultural Mechanics, Wakeman, Chapter 12.
3. Shopwork on the Farm, 2nd ed., Jones, Chapter 4.
4. Shop Demonstrations
   a. #1: Operating the Band Saw
   b. #2: Operating the Sabre Saw
   c. #3: Operating the Belt Sander
   d. #4: Operating the Planer
   e. #5: Operating the Drill Press
   f. #6: Operating the Metal-cutting Band Saw

UNIT - POWER TOOLS

Lesson 1: How can I use power tools safely?

TEACHING PROCEDURES

A. Review

At the start of this unit, review with the class the power tool demonstrations in Animal Science - Agricultural Mechanics. Power tool demonstrations in that curriculum include the abrasive cut-off saw, radial arm saw, table saw, and jointer.

B. Motivation: Take the class to the shop. Ask the students to identify the power tools available in the shop.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students what safety precautions should be followed when using power tools.

What safety precautions should I follow when using power tools?

1) General rules
   a) Wear eye protection and appropriate clothing.
   b) Make sure tools are in good working order and in proper adjustment before operating.
   c) Make sure that cutting tools have sharp blades before using.
   d) Turn the power off in two places - the machine switch and the plug - before adjusting or repairing power tools.
   e) Make sure the work area is clear of scraps and rubbish.
   f) For most power tool operations, there is only one operator, who both handles material and turns the machine on and off.
   g) Make sure all guards are in place at all times.
   h) Have plenty of shadow-free light in the work area.

2) Rules for specific tools

(NOTE: Add to or delete from this list as necessary to fit the power tools available in the shop.)

   a) Table saw
      (1) Study the adjustments and make sure you understand them before starting to work.
      (2) Saw only material that has a straight edge.
      (3) Do not stand in line with the blade while sawing or allow fingers or hands to be in line of cut.
      (4) Use saw guard where possible.
      (5) Use a "push" stick for ripping narrow pieces.

(6) Hold material against the ripping fence when ripping, and the miter gauge when crosscutting. Never saw freehand.
(7) Never use the ripping fence for a gauge when crosscutting short pieces.
(8) Do not place the hands over or in front of the blade. Never reach over the blade.
(9) Turn off the saw before removing short pieces from near the blade.

b) Band saw
(1) Keep hands a safe distance from moving parts, never closer than 2 inchs from the blade.
(2) Use a push block when sawing small stock.
(3) Never reach around a moving blade.
(4) When making a cut, do not place your hand in line with the cutting edge.
(5) Never attempt to remove small pieces of wood from near the blade while the saw is running.
(6) Never leave a running saw unattended.

c) Sabre saw
(1) Clamp work securely to prevent movement or excessive vibration.
(2) Check blade for proper size, sharpness, and tightness in blade holder. Do not use dull, bent, or cracked blades.
(3) After making certain the switch is in the "off" position, connect power cord to power source. Saw must be properly grounded to prevent injury to user.
(4) Maintain a well-balanced position on both feet. Do not shift position of feet while sawing.
(5) Grip handle firmly with the right hand and control turning movements with left hand on the guide knob.
(6) Place toe of base firmly on work before turning on motor.
(7) Do not set saw down or remove blade from an unfinished cut until the motor is stopped.
(8) When finishing a cut, support the cut-off section if it may bind the blade. Bound blades may break, throwing metal pieces some distance.

d) Radial arm saw
(1) Do not leave machine while it is running.
(2) Be sure machine is grounded properly.
(3) Be sure material is free of knots, nail points, or other foreign matter.
(4) Do not adjust machine while it is running.
(5) Tighten rip lock and before starting the saw.
(6) Pull saw slowly through material. Return saw to rear of table after sawing and before removing stock.
(7) When ripping, make sure that the blade is rotating upward toward you. Feed the stock from the end opposite the anti-kickback device. Always use a push stick when ripping.
(8) Do not stop blade by pushing stock against the blade.
(9) Do not saw material freehand without a guide.

e) Belt sander
(1) Never use sanding belt in poor condition.

(2) Check motor switch to see that it is off before connecting to power source.
(3) Check alignment or tracking and tension of belt.
(4) Do not attempt to take material off too fast by excessive pressure and over working the motor.
(5) Unplug sander when not in use.
(6) When not sanding set sander on piece of hardboard near center of bench, where it will not fall or damage the bench top.
(7) Keep the sander clean and well lubricated.

f) Planer
(1) Make sure knives are sharp and properly adjusted.
(2) Make all machine adjustments before turning the machine on.
(3) Make sure motor is at full RPM before feeding material into machine.
(4) Always stand to one side when feeding or receiving stock.
(5) Never attempt to remove more than 1/8-inch on softwoods or 1/16-inch on hardwoods during one pass.
(6) Do not place hands near feed rolls or knives.
(7) If stock gets stuck, shut mahcine off, lower the table bed and remove the stock.
(8) Remove loose knots, nails, or other defects before planing.
(9) Do not plane stock shorter than 12 inches.
(10) Do not plane stock to a thickness of less than 3/8 of an inch without a backer board.
(11) If board is wet, lubricate the bed with kerosene or wax.

g) Jointer
(1) Do not make any adjustments with machine running.
(2) Double check all adjustments before turning on power.
(3) Do not attempt to joint or edge material containing nails, paint, severe knots or other defects.
(4) Do not reach over or around cutterhead while machine is running.

h) Drill press
(1) Clamp the material to be drilled securely to the table.
(2) Place the long end of the peice being drilled to the left so it will hit the post and not the operator should the material slip and start rotating.
(3) Do not feed the drill faster than it can easily cut.
(4) Remove the chips from the machine with brush.
(5) Use care in reaching around the machine.
(6) Keep long hair tied back or covered to keep it from getting wrapped around the chuck.
(7) Be sure chuck is tight on drill and that the drill and chuck match.
(8) Always remove the chuck wrench from the chuck immediately after using it.
(9) Be sure drill is sharp and operating at proper speed.
(10) Never wear gloves while operating the drill press. They may get caught.
(11) Do not drill into a container that may have contained gasoline or other flammable materials.

(12) Support long material being drilled.
(13) Slow the drill feed when the drill is breaking through the material.
(14) Hold round stock in a "V" block.
(15) Clamp sheet metal between two blocks of wood and drill through wood and metal.

i) Metal-cutting band saw
(1) Keep hands away from eyes. Small pieces of metal can be rubbed into the eyes which can cause pain and serious injury to the eyes.
(2) Keep hands a reasonable distance from the blade when cutting.
(3) Keep the adjustable blade guide adjusted as close as possible to the material.
(4) Be sure the metal to be sawed is held securely in the vise.
(5) Make sure the pulley shield is always in place before use.
(6) Allow the blade to feed in the work when starting a cut.
(7) Do not force the speed of cutting by applying pressure.
(8) Support long material.
(9) Do not leave saw running unattended.
(10) Remove the burr left by the saw by filing or grinding.
(11) After the saw has stopped, use a brush not your bare hand to remove chips from the machine.

j) Abrasive cut-off saw
(1) Make sure that the work is clamped securely in the vise before starting the saw.
(2) Support long material.
(3) Do not try to force the saw through faster than it can cut.
(4) Stand to one side when operating the saw. Do not stand directly behind the saw blade when operating the saw.
(5) Do not release the work from the vise until the saw blade has stopped turning.

2. Discuss the shop rules concerning the use of power tools with the students. (Appropriate topics to discuss would include: what condition to leave the floor in; what condition to leave the equipment in; what to do with metal scraps; what to do with wood scraps; and what to do in case of equipment failure.)

What are the shop rules concerning the use of power tools?

(Answers by instructor will vary.)

F. Other Activities

Shop Demonstrations

(Add to or delete from this list as needed to fit the equipment in the shop and as time permits.)

#1 - Operating the Band Saw
#2 - Operating the Sabre Saw
#3 - Operating the Belt Sander
#4 - Operating the Planer

#5 - Operating the Drill Press
#6 - Operating the Metal-cutting Band Saw

G. Summary

When operating power tools, a student should:

1. Wear eye protection and appropriate clothing.
2. Make sure that tools are in good working order and in proper adjustment before use.
3. Follow the specific safety rules for individual tools.
4. Follow the shop rules for operating power tools.

H. Answers to Evaluation

(NOTE: The teacher may also want to administer the safety tests (for power tools studied in this lesson) by HOBAR as an additional evaluation for this lesson. The examinations in the Power Tool Safety and Operation Instructor's Packet are available in pad form from the Instructional Materials Laboratory.)

1. T
2. F
3. F
4. F
5. F
6. T
7. T
8. T
9. F
10. T

UNIT - POWER TOOLS

Lesson 1: How can I use power tools safely?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. When ripping narrow pieces on the table saw or radial arm saw, always use a push stick.

T F 2. To stop the radial arm saw blade more quickly, push the stock against the blade.

T F 3. When drilling with the drill press, exert as much pressure as possible on the drill to punch the hole through more quickly.

T F 4. When cutting through thick material with the metal-cutting band saw, it is good practice to work on other projects while the saw is cutting.

T F 5. Most machine guards are a nuisance and should be removed from power tools as soon as possible after purchase.

T F 6. Never attempt to remove small pieces of wood from near the blade of a bandsaw while the saw is running.

T F 7. When using a sabre saw, always place the toe of the base firmly on the work before turning the motor on.

T F 8. When using portable power tools, such as the belt sander, always check to make sure the switch is off before plugging the tool in.

T F 9. To save time, always adjust power tools while they are running.

T F 10. The work area should be kept clear of scraps and rubbish.

UNIT - POWER TOOLS

SHOP DEMONSTRATION #1: Operating the Band Saw

Objective: At the end of this demonstration, the student should be prepared to use the band saw in the shop.

Tools Needed:

1. Band saw
2. Safety goggles
3. Appropriate clothing

Materials Needed:

1. Scrap lumber suitable for cutting on the band saw

Procedure:

Step 1: Demonstrate how to adjust the upper blade guide for the thickness of lumber to be sawn, adjusting the guide to no more than 1/4-inch above the lumber.

Step 2: Demonstrate how to mark the lumber to be sawn, marking out a ripping exercise, a crosscutting exercise, and a circular cut.

Step 3: Demonstrate how to turn the saw on and off.

Step 4: Demonstrate how to rip with the band saw, using the ripping fence.

Step 5: Demonstrate how to crosscut with the band saw, both freehand and using the miter gauge.

Step 6: Demonstrate how to make circular cuts with the band saw.

UNIT - POWER TOOLS

SHOP DEMONSTRATION #2: Operating the Sabre Saw

Objective: At the end of this demonstration, the student should be prepared to use the sabre saw in the shop.

Tools Needed:

1. Sabre saw, with extra blades
2. Safety goggles
3. Appropriate clothing
4. Hand drill with drill bit larger in diameter than the width of the sabre saw blade.

Materials Needed:

1. Scrap lumber suitable for cutting with the sabre saw.

Procedure:

Step 1: Demonstrate how to replace the blade of the sabre saw.

Step 2: Demonstrate how to adjust the sabre saw, including raising/lowering the base and tilting the base for bevel cuts, if such adjustments are available on the sabre saw being used.

Step 3: Demonstrate marking the work to be cut including straight cuts, curved cuts, and pocket cuts.

Step 4: Demonstrate how to make a straight cut with the sabre saw.

Step 5: Demonstrate how to make a curved cut with the sabre saw.

Step 6: Demonstrate how to make a pocket cut with the sabre saw.

a) Drill a hole in the waste area.
b) Begin sawing from the drilled hole.

UNIT - POWER TOOLS

SHOP DEMONSTRATION #3: Operating the Belt Sander

Objective: At the end of this demonstration, the student should be prepared to use the belt sander in the shop.

Tools Needed:

1. Belt sander
2. Safety goggles
3. Appropriate clothing

Materials Needed:

1. Scrap lumber suitable for sanding with the belt sander.

Procedure:

Step 1: Demonstrate how to change the belt on the sander.

Step 2: Demonstrate sanding with the belt sander.

a) Clamp stock to be sanded in a vise or to the table.
b) Holding the sander in both hands, start the sander either above the work or at one end of the work.
c) Allow the rear of the sander to touch first, leveling the sander as it is moved forward.
d) Move the sander lightly over the work, moving the sander in the same direction or with the grain.
e) Raise the sander slightly at the end of the stroke.
f) Begin the second stroke, overlapping the first by half a stroke.
g) Continue across the width of the board.
h) Change to a finer grit belt until the desired finish is reached.

UNIT - POWER TOOLS

SHOP DEMONSTRATION #4: Operating the Planer

Objective: At the end of this demonstration, the student should be prepared to use the planer in the shop.

Tools Needed:

1. Planer
2. Safety goggles
3. Appropriate clothing
4. Hearing protection

Materials Needed:

1. One piece of rough sawn lumber

Procedure:

Step 1: Demonstrate how to adjust the planer.

Step 2: Demonstrate how to turn the planer on and off.

Step 3: Demonstrate how to operate the planer.

a) Determine the desired thickness and the starting thickness. Measure the board at its thickest point.
b) Set the planer for the thickness of the board less the depth of cut. (Recommended depth of cut per pass is 1/16-inch for hardwoods; 1/8-inch for softwoods.)
c) Adjust the feed roll speed.
d) Turn on the planer and allow it to come up to full speed.
e) Feed the stock in at right angles to the cutter head.
f) Allow the machine to feed the board in.
g) Repeat passes as needed to gain the desired thickness.

UNIT - POWER TOOLS

SHOP DEMONSTRATION #5: Operating the Drill Press

Objective: At the end of this demonstration, the student should be prepared to use the drill press in the shop.

Tools Needed:

1. Drill press, with 1/4-inch and 1/2-inch drill bits
2. Safety goggles
3. Appropriate clothing
4. Hand brush

Materials Needed:

1. One piece of scrap 1/4-inch flat hot rolled mild steel (HRMS) plate
2. Water soluble oil

Procedures:

Step 1: Demonstrate how to adjust the drill press for height of table and depth of hole.

Step 2: Demonstrate how to set the speed of the drill press for the bit size used.

Step 3: Demonstrate how to mark the hole to be drilled and how to center punch the hole.

Step 4: Demonstrate how to turn the drill press on and off.

Step 5: Demonstrate how to fasten the bit securely in the chuck.

Step 6: Demonstrate how to position the work and fasten the work securely in the vise. Place the work over a block of wood to prevent damage to the table.

Step 7: Demonstrate drilling a hole with the drill press.

a) Feed the drill into the material at a constant rate.
b) Cool the bit and work periodically with the water soluble oil.
c) Deburr the hole using the 1/2-inch drill bit.

UNIT - POWER TOOLS

SHOP DEMONSTRATION #6: Operating the Metal-cutting Band Saw

Objective: At the end of this demonstration, the student should be prepared to use the metal-cutting band saw in the shop.

Tools Needed:

1. Metal-cutting band saw
2. Safety goggles
3. Appropriate clothing
4. Leather gloves

Materials Needed:

1. Short lengths of pipe, square tubing, channel iron, angle iron, and flat steel suitable for sawing with the metal-cutting band saw
2. Water soluble oil

Procedure:

Step 1: Demonstrate how to turn the saw on and off.

Step 2: Demonstrate how to clamp the stock firmly in the vise for each type of steel.

Step 3: Demonstrate how to position the work in the vise.

Step 4: Demonstrate how to adjust the blade guides as close to the work as possible.

Step 5: Demonstrate how to saw metal with the metal-cutting band saw.

a) Raise the blade and start the saw.
b) Lower the blade gently onto the work.
c) Allow the saw to saw completely through the work on its own.
d) Allow the saw to shut off automatically at the end of the cut.
e) Release the metal from the vise.

UNIT - PAINTING

Lesson 1: How do I spray paint my project?

Objective: At the end of this lesson, the student will be able to spray paint a completed shop project.

Study Questions:

1. **Which type of spray painting system should I use?**
2. **What are the parts of a conventional spray gun?**
3. **What safety precautions should I observe when spray painting?**
4. **How should I prepare the surface for spray painting?**
5. **What primer and paints should I use for spray painting?**
6. **What procedures should I follow when spray painting?**
7. **What are some common problems which occur when spray painting?**

References:

1. Transparency Masters
   a. TM-1: Types of Spray Systems
   b. TM-2: Parts of a Spray Gun
   c. TM-3: Parts of a Spray Gun-Key
   d. TM-4: Spray Patterns
   e. TM-5: Positioning the Spray Gun
   f. TM-6: Spray Painting Technique
   g. TM-7: Spray Painting a Panel
   h. TM-8: Special Spray Painting Techniques
2. Handout
   a. HO-1: Spray Painting and Spray Painting Equipment
3. Shop Demonstration
   a. #1 - Spray Painting
4. Shop Exercise
   a. #1 - Spray Painting

UNIT - PAINTING

Lesson 1: How do I spray paint my project?

TEACHING PROCEDURES

A. Review with the students Lesson 1 in Agricultural Mechanics for Animal Science, pp. 245-261. Important points in the review should include:

1. Preparation of surfaces to be painted.
2. Selection of the proper paint for various applications.

B. Motivation: Show a spray painting gun to the class. Ask the students to identify the gun. Then ask the students to name some uses for the spray gun.

C. Assignment: Have the students read HO-1.

D. Supervised Study

E. Discussion

1. Show TM-1 to the students. Ask the students to identify the three types of spray painting systems. List these on the chalkboard. Ask the students to list the advantages of each one.

Which type of spray painting system should I use?

1) Types of spray systems.
   a) Conventional
   b) Hot spray
   c) Airless spray
2) Advantages of the conventional systems (most common type).
   a) Versatility in the type of paint which can be used.
   b) Allows a wider selection of spray pattern sizes, degrees of atomization, and wetness of coat.
3) Advantages of hot spray systems.
   a) Better for applying paints with high solids content.
   b) Produces a heavier coat.
   c) Less shrinkage during drying.
   d) Less overspray.
   e) Can be used more effectively at lower temperatures than other types.
4) Advantages of airless spray systems.
   a) Good for large surface coverage without overspray.
   b) Light weight, which enables easier manipulation of the gun.

2. Show TM-2 to the students. Ask the students to identify the parts of a conventional spray gun. Use TM-3 as an overlay to insure that the parts have been correctly identified.

What are the parts of a conventional spray gun?

1) Trigger

2) Air valve
3) Fluid adjustment screw
4) Spreader adjustment valve
5) Air cap
6) Wing ports
7) Fluid tube
8) Fluid tube screen

3. Ask the students to identify safety precautions to follow when spray painting.

What safety precautions should I observe when spray painting?

1) Read the label.
2) Wear a respirator.
3) Check the respirator before use.
4) Wear safety goggles or glasses.
5) Wear appropriate clothing.
6) Wear rubber gloves, especially when applying paint removers or etching materials.
7) Only work in a well-ventilated area.
8) Use equipment properly.
9) Store flammable materials properly.
10) Keep the spray area clean.
11) Clean up spills promptly.
12) Keep covers on paint and solvent containers.
13) Never spray around electric motors other than the explosion-proof type.
14) Know the location of the fire extinguishers.
15) Keep the spray away from open flames.

4. Ask the students how to prepare the surface for spray painting.

How should I prepare the surface for spray painting?

1) Clean the surface with a solvent cleaner, washing a small area at a time, then drying with clean cloths.
2) For painted surfaces in good condition:
   a) Sand all broken paint areas and feather in the edges of old paint areas.
   b) Dry-sand the entire area to be painted.
   c) Etch all bare metal areas with a metal conditioner.
   d) Wipe off any excess metal conditioner and wipe dry with clean cloths before priming.
3) For painted surfaces in poor condition:
   a) Remove all old paint with a grinder, chemical paint remover, or sandblasting.
   b) Use a metal conditioner.
   c) Wipe off any excess metal conditioner and wipe dry with clean cloths before priming.
4) For bare steel and other ferrous metal surfaces:
   a) Use a metal conditioner.
   b) Wipe off any excess metal conditioner and wipe dry with clean cloths before priming.

5. Ask the students how to select primer and paint for spray painting.

What primer and paints should I use for spray painting?

1) Choice of primer-paint system will depend on:
   a) Environment the painted object will be used in
   b) Method of application
   c) Cost
2) Systems will vary in:
   a) Type of surface preparation required
   b) Primer
   c) Drying time (for both paint and primer)
   d) Areas of use for each system

6. Ask the students how to prepare the paint for painting. Show TM-4 to the students. Ask the students what must be done to correct each abnormal spray pattern. Show TM-5, TM-6, TM-7, and TM-8 to the students. Ask the students to identify procedures to follow when spray painting.

What procedures should I follow when spray painting?

1) Spray a coat of primer on the surface. Let dry.
2) Prepare the paint for painting.
   a) Stir the paint.
      (1) Agitate thoroughly.
      (2) Empty the contents into a clean container.
      (3) Wash the can clean with a small amount of a compatible thinner, then add this material to the paint.
      (4) If a hard layer has settled out, pour off the liquid part, break up the hardened layer, then pour the liquid part back in a little at a time while stirring vigorously.
   b) Thin or reduce the paint.
      (1) The amount to use will depend on the temperature of the painting area.
      (2) Follow directions on the label for amounts of thinner or reducer to add as well as the type of thinner to use.
   c) Strain the paint.
3) Adjusting the spray gun
   a) Set the pressure on the regulator at 30 to 40 pounds.
   b) Test the spray pattern by holding a clean sheet of paper approximately 8 inches from the gun and briefly press the trigger.
   c) Abnormal spray patterns (Refer to TM-4.)
      (1) Split spray - caused by air pressure which is too high or paint material being too thin. Corrective action - close the spreader adjustment valve slightly (for excessive air pressure) or open the fluid adjustment screw slightly and close the spreader adjustment valve slightly (for thin paint material).
      (2) Fan spray - caused by the air pressure being too low. Corrective action - opening the spreader adjustment valve until a normal spray pattern is reached.

(3) Crescent spray - caused by a restriction through the wing ports. Corrective action - clean the wing ports in solvent (never by using a metal instrument).

4) Spray painting the surface
   a) Hold the spray gun approximately 8 inches away from the surface, at 90 degrees to the work. (Refer to TM-5.)
   b) Move the gun parallel to the surface being painted. (Refer to TM-6.)
   c) For painting large flat areas: (Refer to TM-7.)
      (1) Paint the edges first.
      (2) Make the first pass at the top of the panel, moving left to right, while aiming the gun so that the middle of the spray pattern is at the top edge of the panel.
      (3) Begin each pass by pointing the gun at a point 2 to 3 inches outside the panel, pulling the trigger, then moving at a constant speed across the face of the panel.
      (4) Continue the stroke to the same distance beyond the panel and release the trigger.
      (5) Move down and make the second pass from right to left, aiming the gun so that the middle of the spray pattern is at the bottom of the previous pass.
      (6) Continue this procedure, alternating left to right and right to left strokes, until the panel is completed.
   d) Special painting techniques which may be needed: (Refer to TM-8.)
      (1) For thin, vertical surfaces, use a vertical spray patern.
      (2) Paint inside corners as though there were two flat surfaces.
      (3) For painting narrow edges, use a banding technique.
      (4) Paint outside corners using a horizontal spray pattern, aiming the gun so that the middle of the spray pattern is at the point of the corner.
   e) Direct overspray onto unpainted areas - for projects, paint all edges first.
   f) Be careful of overspray - droplets of paint can be carried great distances and land where they are not wanted.

5) Cleaning the gun:
   a) Loosen the air cap 2 or 3 turns.
   b) Remove the paint cup.
   c) Positioning the spray gun over the cup, hold a loosely wadded cloth over the air cap and pull the trigger to release any paint still in the gun back into the cup.
   d) Lay the gun aside.
   e) Empty the cup of all paint and clean it thoroughly.
   f) Fill the cup about half full of an appropriate solvent.
   g) Reassemble the gun and spray the solvent through the gun.
   h) Disconnect the air supply.
   i) Remove the air cap and soak it in solvent to remove any dried paint.

j) Use solvent to clean the outside of the gun.
k) Reassemble the gun.

7. Ask the students to name some common problems encountered when spray painting. List these on the chalkboard. Ask the students to identify the causes of each and the corrective action needed.

What are some common problems which occur when spray painting?

1) Runs and sags
   a) Cause - application of a paint coat that is too thick
   b) Corrective action - If the paint is still wet, brush out sags using a fine camel-hair brush or remove the excess paint using a piece of nylon hose; then recoat. If the paint is dry, sand the sag down and refinish.
2) Blisters
   a) Cause - painting over grease or oil.
   b) Corrective action - sand down and refinish.
3) Peeling
   a) Cause - poor surface preparation.
   b) Corrective action - refinish.
4) Shriveling or wrinkling
   a) Cause - not allowing coats of enamel to dry adequately before recoating or by applying lacquer over enamel.
   b) Corrective action - remove wrinkled finish and refinish.
5) Rust areas
   a) Causes - poor surface preparation or water in the air lines.
   b) Corrective action - take the finish down to bare metal and treat with metal conditioner before refinishing.

F. Other Activities

Shop Demonstration
#1 - Spray Painting

Shop Exercise
#1 - Spray Painting

(NOTE: The demonstration should be done at the time of the class lesson. The student should complete the shop exercise by spray painting the shop projects constructed during the project construction portion of Plant Science - Agricultural Mechanics.)

G. Summary

When spray painting, a student should:

1. Follow safety precautions, such as wearing a respirator and appropriate clothing, and avoiding the danger of explosion and fire.
2. Prepare the surface for painting by washing with solvent cleaner, following appropriate procedures for the type of surface, and using a metal conditioner to prevent rust.
3. Select the appropriate primer - paint system for the environment, method of application, and cost involved.

4. Follow the appropriate procedures for painting by preparing the paint, adjusting the gun, painting the surface, and cleaning the gun.

H. Answers to Evaluation

1. F
2. T
3. T
4. T
5. T
6. T
7. F
8. T
9. F
10. F

UNIT - PAINTING

Lesson 1: How do I spray paint my project?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. When painting a large flat surface, the edges of the area should be painted last.

T F 2. The electrical system and all electric motors in the spray painting area should be explosion-proof.

T F 3. Applying a paint coat that is too thick will cause runs and sags.

T F 4. All steel surfaces should be treated with a metal conditioner before priming.

T F 5. One advantage of conventional spray systems is the versatility in the type of paint which can be used.

T F 6. Always move the spray gun parallel to the surface being painted.

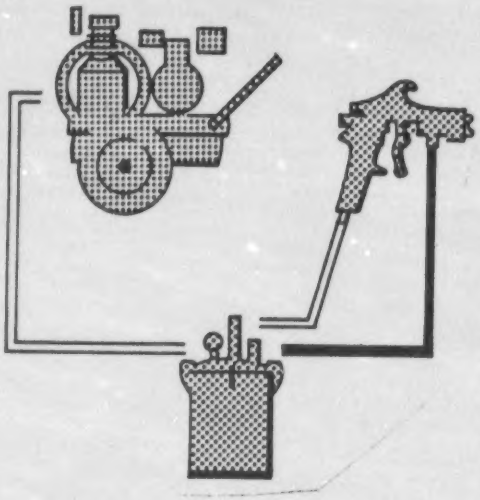
T F 7. It is not necessary to wear a respirator when spray painting acrylic urethane enamels.

T F 8. The first step in preparing the surface to be painted is to clean the surface with a solvent cleaner.

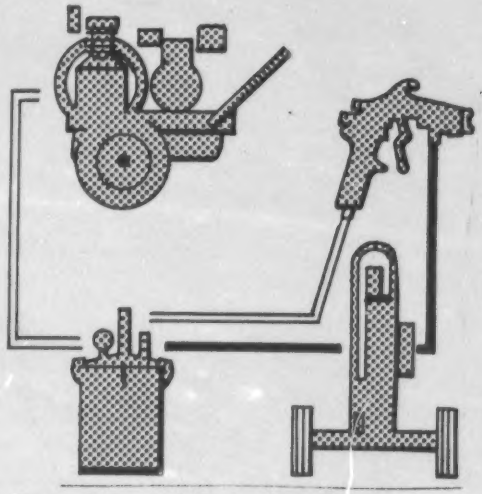
T F 9. Paint direct from the can seldom needs thinning to be the correct consistency for spray painting.

T F 10. The spray gun should be held approximately 15 inches from the surface to be sprayed.

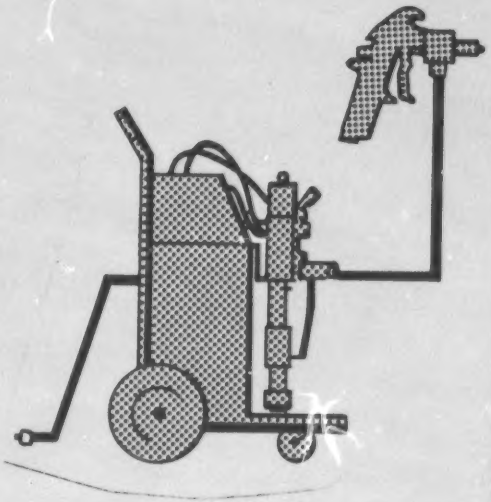
Types of Spray Systems



CONVENTIONAL SPRAY



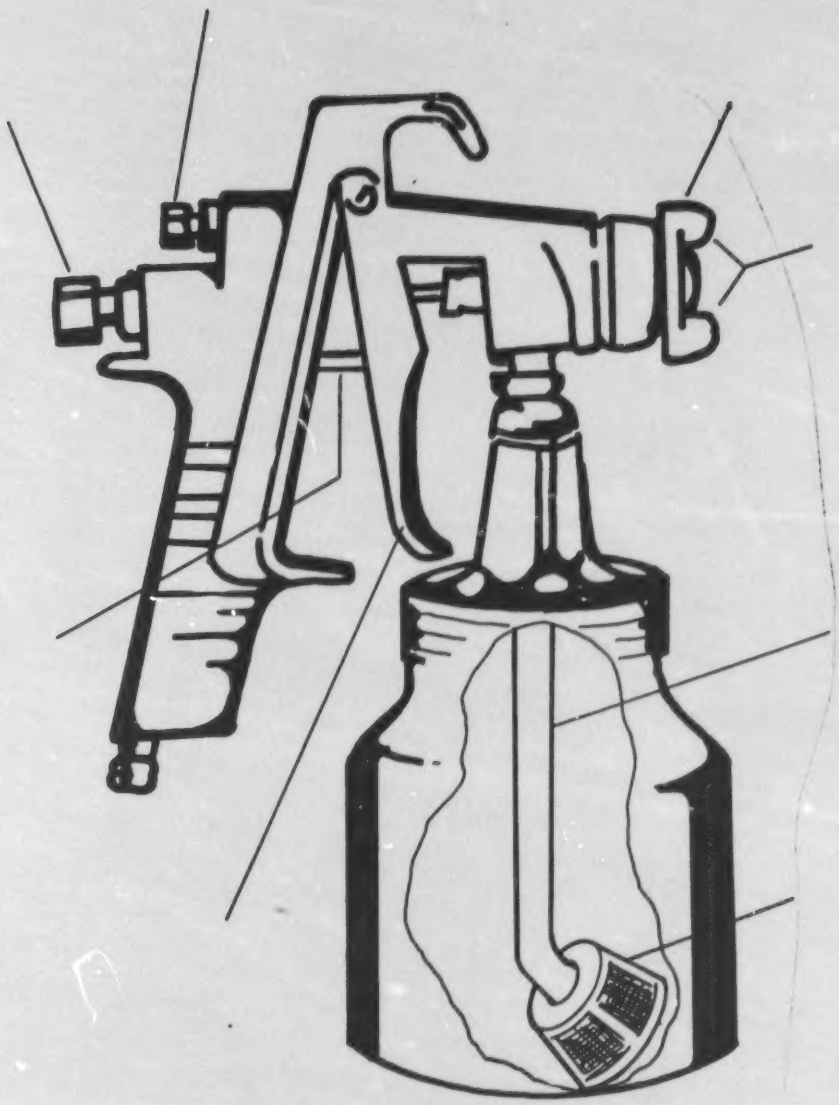
HOT SPRAY



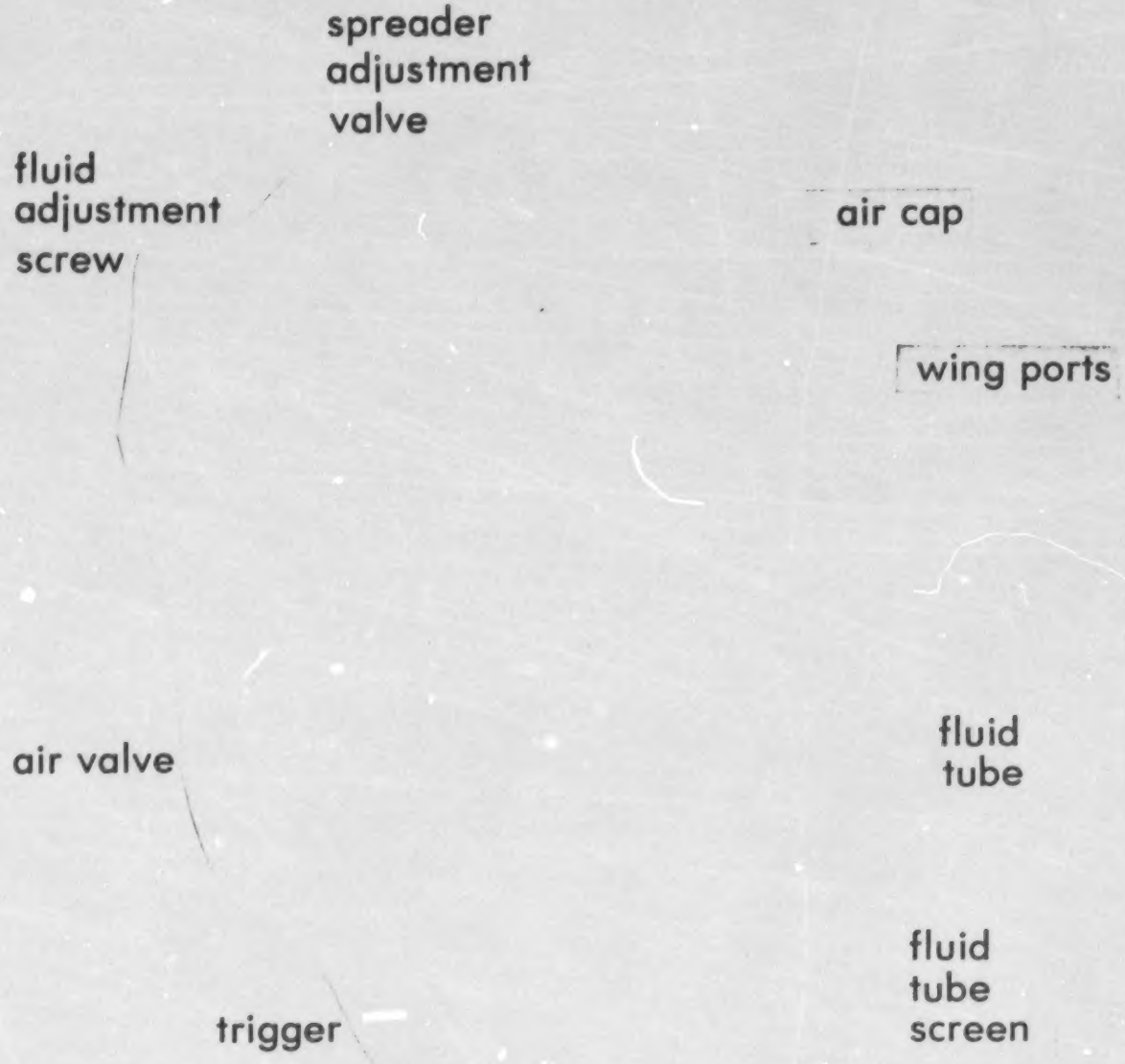
AIRLESS SPRAY

TM-1

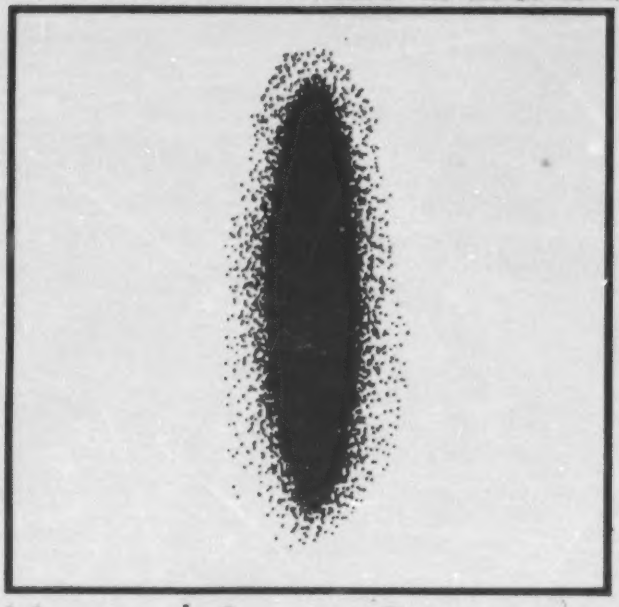
Parts of a Spray Gun



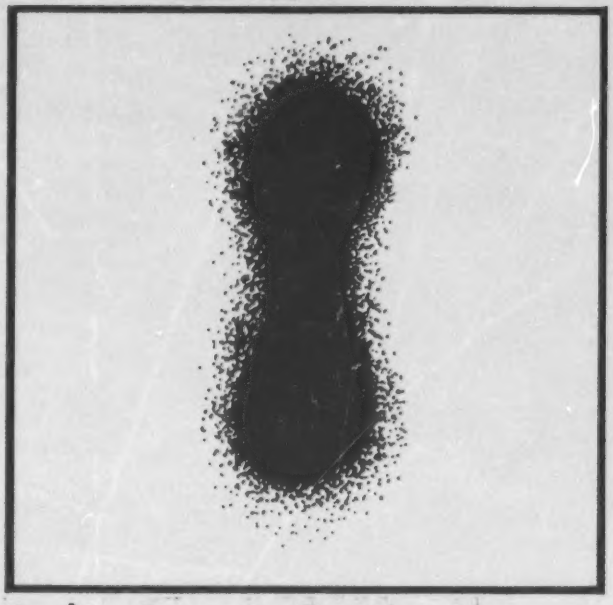
TM-3 Key


spreader
adjustment
valve
fluid
adjustment
screw
air cap
wing ports
air valve
fluid
tube
fluid
tube
screen
trigger

Spray Patterns



Normal Spray Pattern



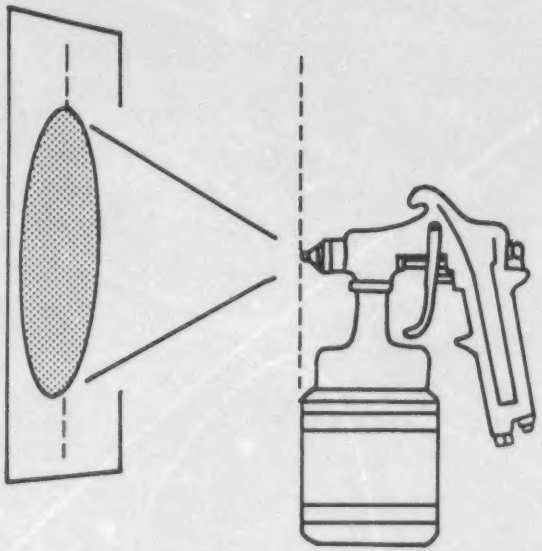
Split Spray Pattern

Fan Spray Pattern

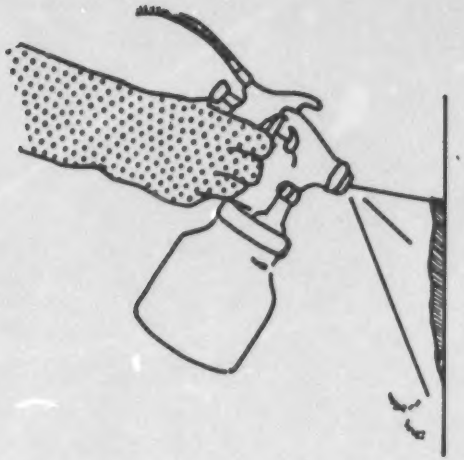
Crescent Spray Pattern

Positioning the Spray Gun

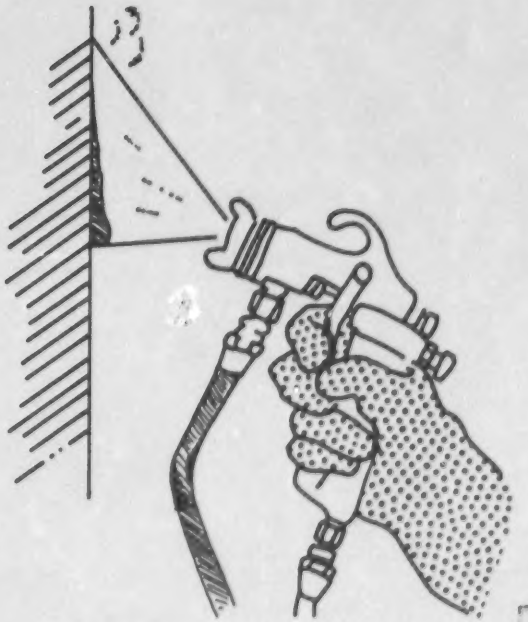
correct



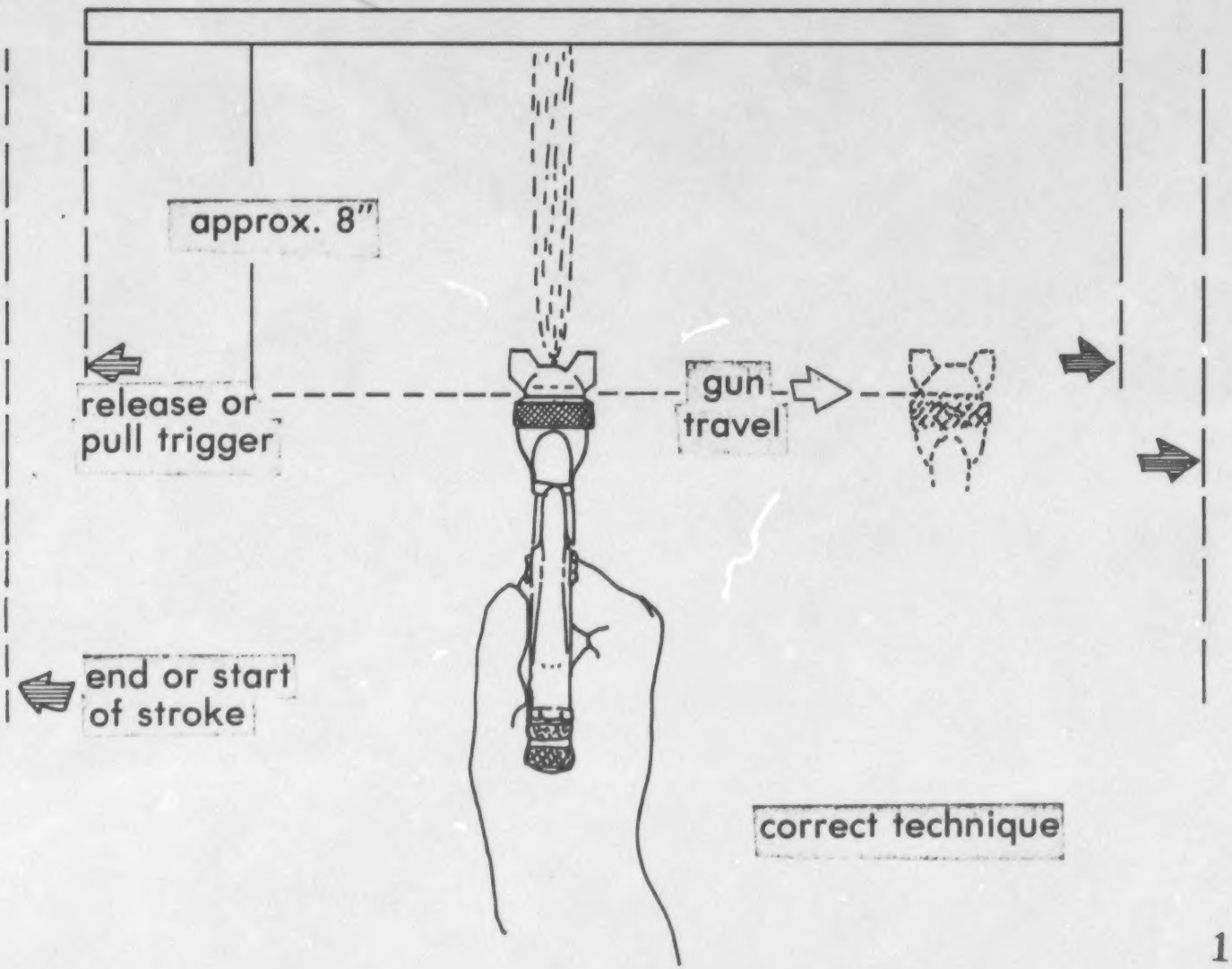
incorrect



incorrect

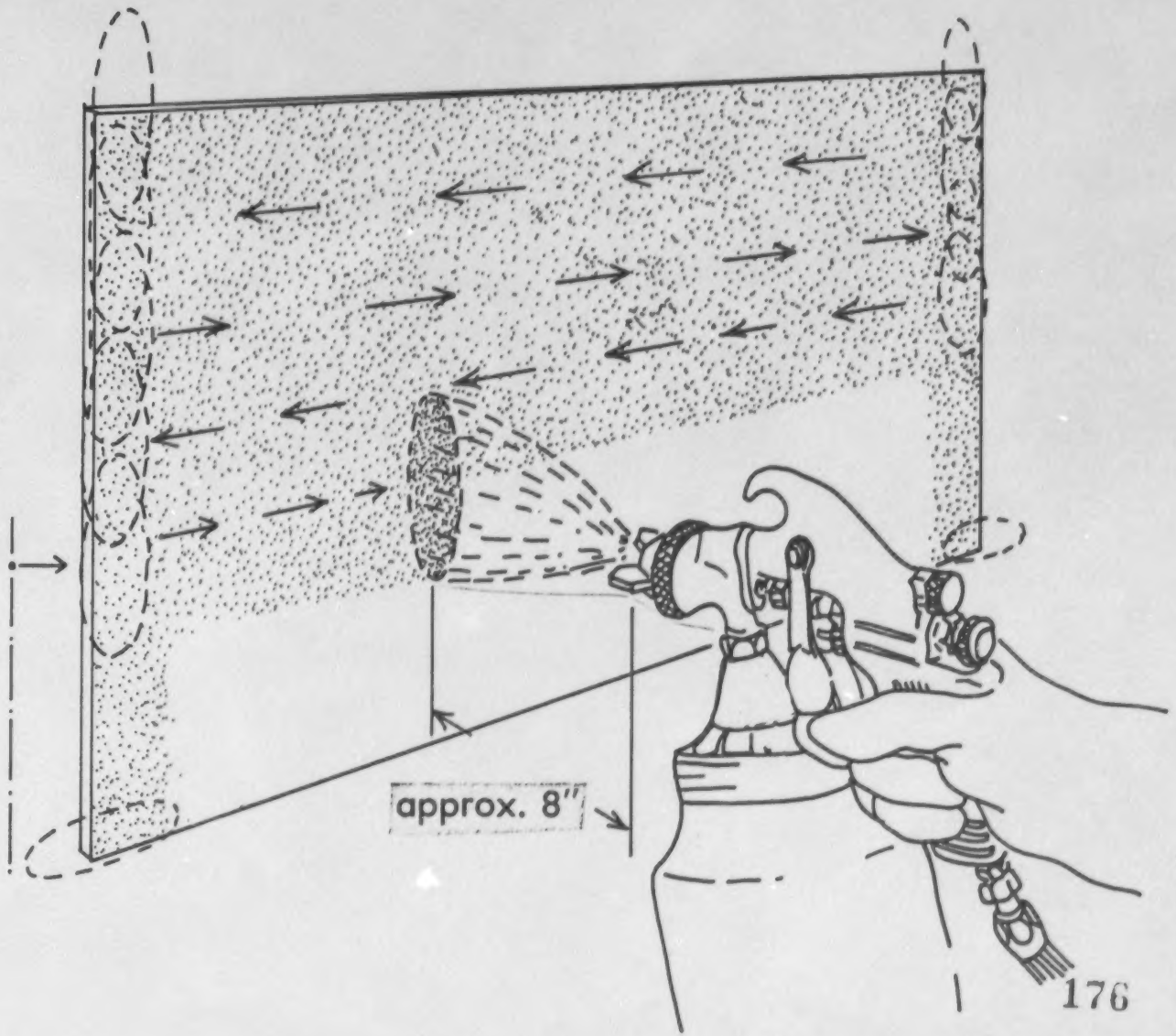


Spray Painting Technique



correct technique

Spray Painting a Panel



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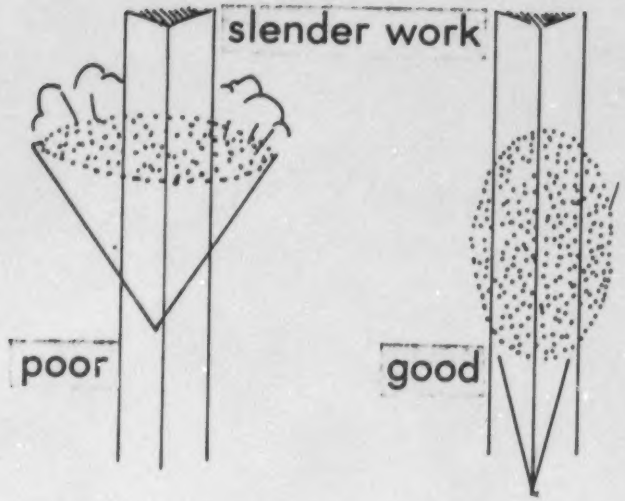
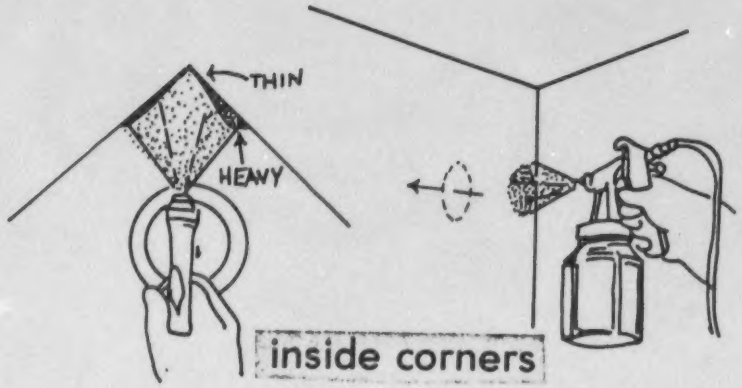
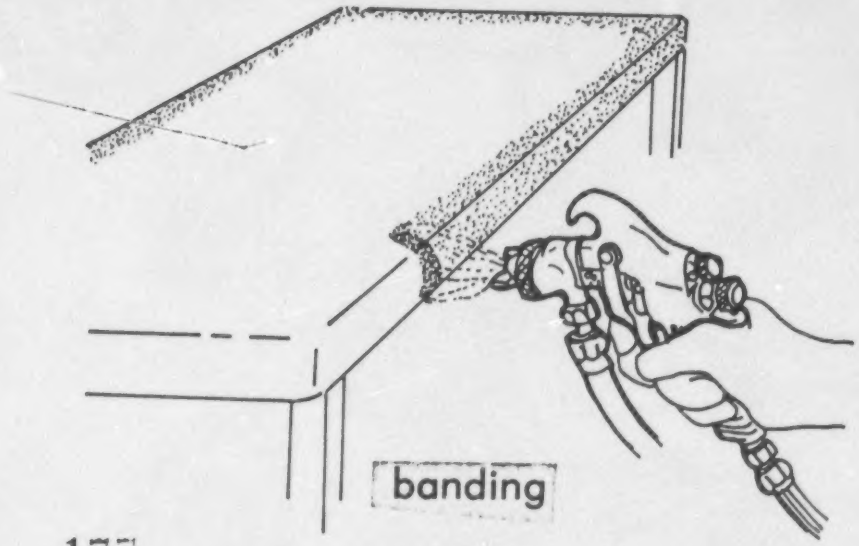
176

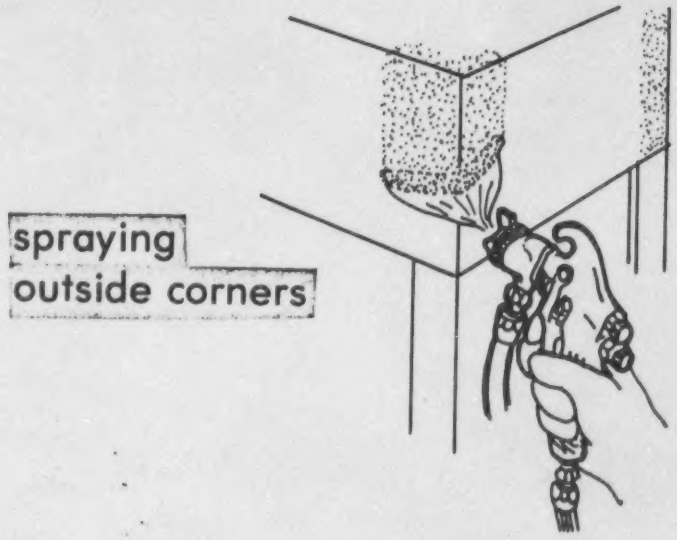
TM-7

Special Spray Painting Techniques









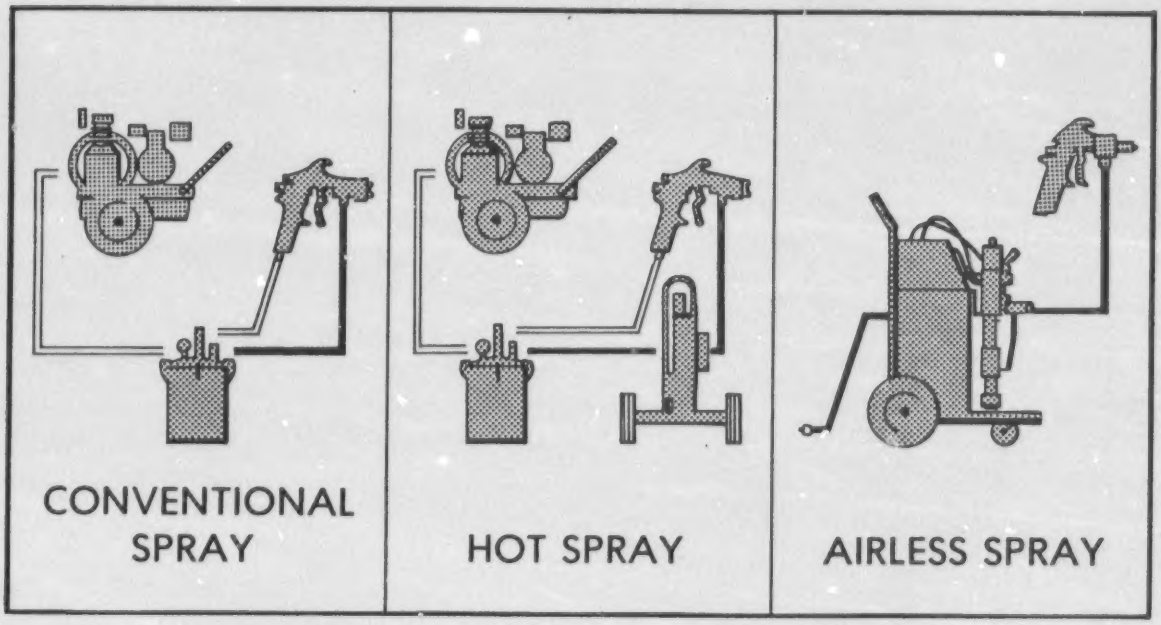
TM-8

SPRAY PAINTING AND SPRAY PAINTING EQUIPMENT

Spray painting has become the method of choice of professional painters for many applications today. This has occurred for many reasons, including speed, quality of the finish, and ease of application. For many of the same reasons, spray painting is often used to protect finished vocational agriculture shop projects. This lesson explores the equipment used to spray paint and the procedures needed to produce a high quality finish.

Types of Spray Painting Systems

There are three common types of spray painting systems - conventional spray systems, hot spray systems, and airless spray systems. These types are illustrated.



Conventional spray equipment is the most commonly used of the three types. This type uses compressed air to atomize the paint at the nozzle of the gun and to feed the paint under pressure from the container (a supply tank, pump, or cup attached to the gun). This type has a great deal of versatility in the type of paint which can be used. The conventional spray unit allows the user a wider selection of spray pattern sizes, degrees of atomization, and wetness of the coat. When these factors are important to the results of the job, this is the most practical choice.

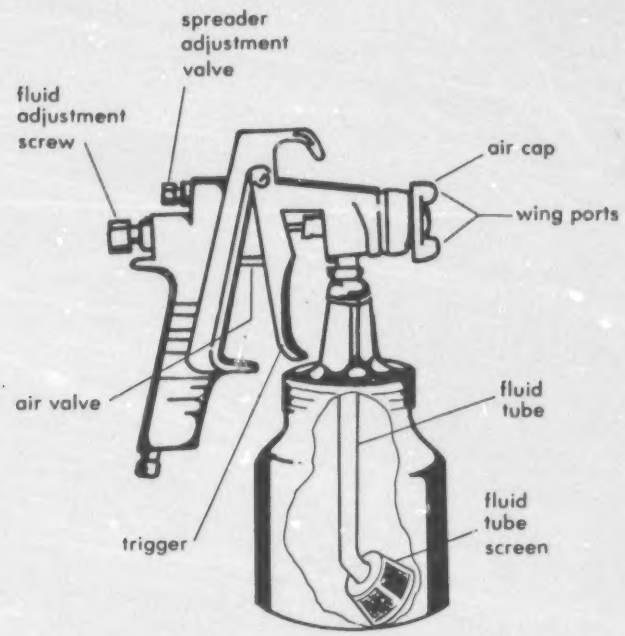
A hot spray unit is much like a conventional unit. It utilizes compressed air in the same ways that a conventional spray unit does. The hot spray unit uses a heater to heat the paint to temperatures of 100° to 180° F. This provides advantages in applying paints with higher solid contents. It also produces heavier coats and reduces shrinkage during

drying. Lower air pressures can be used to get effective atomization of the paint, which in turn reduces overspray. This unit can be used effectively when temperatures are below the 60 to 70 degree minimum needed for other types.

In the airless type, the spray occurs when paint is forced at very high pressures through a restricted opening. This type atomizes the paint without using air jets, thus the name airless spray. A high pressure pump (usually electric) pressurizes the liquid to as high as 1900 pounds per square inch (psi). The pressurized liquid is then delivered to the gun through a single hose line. An airless system can be used effectively to cover large surfaces with wide angle spray without overspray. Because this system uses a single, small diameter hose for delivery of the paint to the gun, manipulation of the gun is easy because of the light weight. The spray pattern produces a quick film build-up, but the operator must be very careful on lapping and stroking to avoid the kind of heavy build-up which causes runs, sags, and wrinkles.

Parts of a Conventional Spray Gun

The following illustration depicts the important parts of conventional spray gun.



The purpose of the trigger is, of course, to start the flow of air and paint material through the gun. The trigger depresses the air valve. Depressing the trigger halfway releases only air. To paint, the trigger must be depressed completely. The width of the spray pattern is adjustable with the spreader adjustment valve. The thickness of the paint coat can be adjusted with the fluid adjustment screw. Compressed air comes through the air cap to the wing ports, flattening out the spray pattern. Paint comes from the cup through the fluid tube. The fluid tube strainer serves as a safety valve to keep any lumps or foreign material from the internal works of the gun.

Safety Precautions While Spray Painting

The greatest dangers to operators of spray painting equipment come from harmful vapors, dusts, and mists or from the possibility of fires and explosions. The following safety precautions try to limit these dangers:

1. Read the label. The label will specify any special precautions, handling instructions, etc., that may be necessary when using a particular product.

2. Wear a respirator. A fresh air supplied respirator is best, but a cartridge type respirator (with an activated charcoal filter) is adequate for most applications.

3. Check the respirator before use. If the respirator fits and the charcoal filter is working properly, the operator should not be able to smell paint fumes. Replace filters as recommended by the manufacturer.

4. Wear safety goggles or glasses. Wearing protective eyewear is important during both surface preparation (grinding or wire brushing) and spray painting.

5. Wear appropriate clothing. Wear long sleeved shirts when painting. Some of the paints, primers, etc., contain chemicals which irritate the skin on contact. If your clothing becomes saturated with these chemicals, change clothes immediately.

6. Wear rubber gloves. This is especially important when applying paint removers or etching materials.

7. Only work in a well-ventilated area. This will limit exposure to harmful vapors, dusts, and mists.

8. Use equipment properly. The pressures used for spray painting can be hazardous if misused. The high pressures used in airless systems are high enough to inject paint into the skin, causing serious injury and requiring immediate treatment.

9. Store flammable materials properly. Store these materials in a fireproof cabinet away from the paint area.

10. Keep the spray painting area clean. A combination of dust and residues from differing types of paint can spontaneously combust.

11. Clean up spills promptly. Do not use sawdust to absorb a spill.

12. Keep covers on paint and solvent containers. The vapors and droplets of paint are as explosive as gasoline.

13. Never spray around electric motors other than the explosion-proof type. On other types the spray mist can be ignited when the motor starts. Electrical outlets and connections around paint storage areas and spray painting booths should also be explosion-proof.

14. Know the location of the fire extinguishers.

15. Keep the spray away from open flame. Spray droplets and paint vapors are very explosive.

Surface Preparation for Spray Painting

The first step in surface preparation is to clean the surface. This is essential to remove any oil, dirt, rust, or moisture which can cause the new paint coating to fail. Washing with a solvent cleaner made for this purpose will remove these substances. Solvent washing should be done by washing a small area at a time, then drying with plenty of clean cloths. Be sure to wear rubber gloves when applying these solvents.

For painted surfaces in good condition:

1. After the solvent washing, sand all broken-paint areas to remove rust and loose paint. Feather in the edges of old paint areas.

2. Dry-sand the entire area to be painted.

3. Etch all bare metal areas with a metal conditioner to check rust. Follow the directions on the metal conditioner carefully.

4. Wipe off any excess metal conditioner with a wet cloth, scrubbing thoroughly. Wipe dry with clean cloths before proceeding with priming.

For painted surfaces in poor condition:

1. After the solvent washing, all of the paint must be removed. This can be done one of three ways - grinder, chemical paint removers, or sandblasting.

2. After the old paint is removed, use a metal conditioner to check rust. Follow directions on the label.

3. Wipe off excess metal conditioner with a wet cloth, scrubbing thoroughly. Wipe dry with clean cloths before proceeding with priming.

For bare steel and other ferrous metal surfaces:

1. After the solvent washing, use a metal conditioner to prevent rust formation. Follow the directions on the label.

2. Wipe off excess metal conditioner with a wet cloth, scrubbing thoroughly. Wipe dry with clean cloths before proceeding with priming.

Selecting Primers and Paints

After the surface has been prepared, the area is ready to be primed and painted. The choice of which paint and primer to use will depend on the conditions which the painted object will work under, the method of application, and cost.

The following table summarizes the properties of four common paint systems.

	Acrylic Latexes	Alkyd Enamels	Epoxy Esters	Acrylic Urethanes
Description	An emulsion of a thermoplastic acrylic resin in water.	A resin with drying oil and polyester components.	Epoxy resin modified with a drying oil, usually dissolved in mineral spirits.	Combination of thermosetting acrylic resin and light-stable aliphatic isocyanate adduct. Solvents used are lacquer-type blends of aromatics and esters.
Surface preparation	Sandblast to near white metal	Power Tool or Sandblast Cleaning	Power Tool or Sandblast Cleaning	Power Tool or Sandblast Cleaning
Application	Spray (Minimum application temperature 50°F.)	Spray, brush, or roll (Minimum application temperature 40°F.)	Spray, brush, or roll (Minimum application temperature 40°F.)	Spray (2-package... curing agent added prior To use) Limited pot life. (Minimum application temperature 55°F.)
Suggested Primer	Acrylic red lead	Red lead-iron oxide, white inhibitive, or zinc chromate	Red lead epoxy ester or Red lead-iron oxide	Epoxy
Primer Drying Time -to touch -to paint over	 15 Minutes 1 Hour	 3 to 4 Hours 24 Hours	 2 to 4 Hours 24 Hours	 1 Hour Overnight
No. of Primer Coats	1	1	1	1
Paint Drying Time -to handle -to recoat	 15 Minutes 1 Hour	 2 to 3 Hours 18 to 24 Hours	 2 to 3 Hours 18 to 24 Hours	 2 Hours 16 to 24 Hours
Number of Paint Coats	1	2	1 or 2	1 or 2
Gloss and Color Retention	Excellent	Very Good	Poor	Excellent
Resistance to	Acids and Alkali-Fair. Water, neutral salts, oils and gasoline-Fair. Strong solvents-Fair.	Acids-Fair. Water, oils, and gasoline-Good. Alkali and strong solvents-Poor.	Acids and solvents-Fairly good. Water, oils and gasoline-Good. Alkali-Poor.	Acids, alkali, water, salts, oils, gasoline-Very Good. Strong solvents-Good.
Steel Corrosion Protection	In recommended environments-Very Good	In recommended environments-Very Good	In recommended environments-Very Good	Excellent (As topcoat)
Areas of Use	Rural, industrial, chemical and marine Not for immersion.	Rural and light industrial. Not for immerson.	Rural, industrial, chemical and marine. Not for immersion.	Heavy industrial, chemical, marine. Splash and spillage. Not for immersion.

These systems would be appropriate for most agricultural applications. For example, most paints used on farm machinery are of the alkyd enamel type.

Important differences in the paints shown would include differences in the type of surface preparation required, primer, drying times, and areas of use for each system.

Spray Painting Procedures

After the surface is clean, it is ready for a coat of primer. Primer seals the surface and provides a better surface for the paint coats to adhere to.

One of the first steps in spray painting is to prepare the paint to be sprayed. If the paint is not properly stirred and thinned or reduced, the paint job will not be satisfactory. Pigment is the part of the paint which settles out. If the job is a large one requiring more than one can of paint and the paints are not properly stirred, the colors may not match.

To stir the paint, agitate the paint thoroughly, then empty the contents into a clean container. Wash the can clean with a small amount of a compatible thinner and add this to the paint. If the paint has settled to a hard layer on the bottom of the can, pour off the liquid part and break up the hardened layer. Pour the liquid part back in a little at a time, while stirring vigorously. Do not use sharp sticks or screwdrivers to stir paint. Instead, use a flat-bottomed, clean stirring paddle (at least one inch wide) to stir the paint.

To obtain the proper consistency of paint for spray painting, the paint must be reduced or thinned. The proper amount of thinner to be added will depend on the shop temperature. As the shop temperature cools, the paint will become thicker, requiring more thinner to obtain the needed paint flow. Follow the direction on the paint can carefully for thinning instructions.

After thinning and stirring, strain the paint to remove lumps and any foreign material. Paper strainers work well; they are available at a minimal cost from your paint supplier. Old nylons or cheesecloth can also be used to strain the paint.

Before putting paint in the gun to begin painting, make sure that you have the appropriate solvent on hand for cleaning the gun. Paint hardens in the passageways of the gun very quickly - so quickly that you will not have time to run back to the paint store to get solvent if you finish painting and find that you do not have the right type.

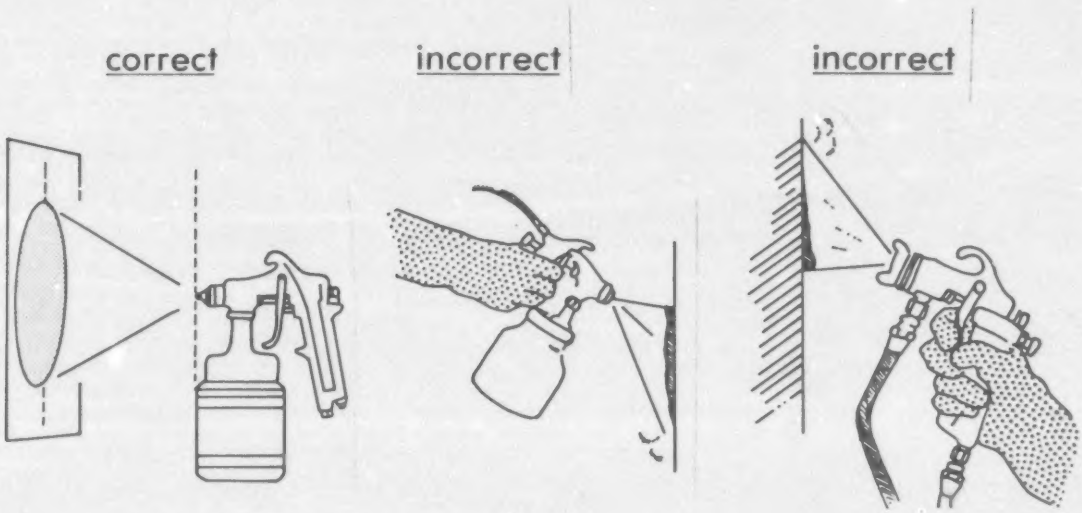
Set the pressure on the air regulator at 30 to 40 pounds. This is the pressure needed at the gun. There will be a pressure drop from the air pressure reading on the regulator and the actual air pressure at the gun. The amount of the pressure drop will vary with the diameter of the hose and the length of the hose. Experiment within this range until you get proper atomization of the paint.

After filling the gun with paint, test the gun for adjustment. Take a clean sheet of paper and hold it approximately 8 inches from the gun. Pull the trigger all the way back, then release the trigger. Examine the paper. The pattern will usually look like one of the following spray patterns.

Normal Spray Pattern | Split Spray Pattern | Fan Spray Pattern | Crescent Spray Pattern

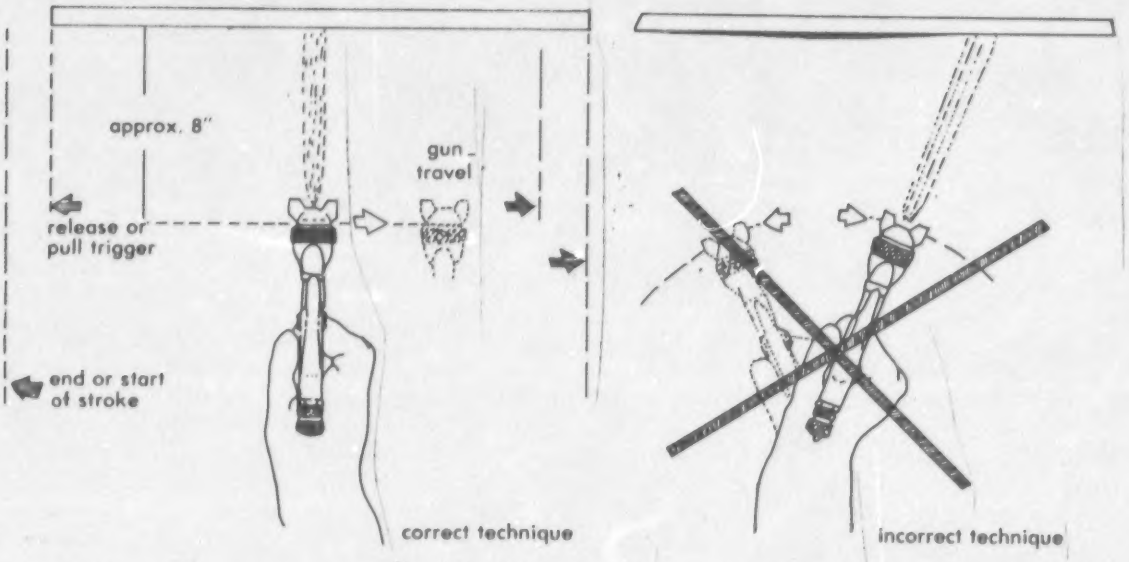
If the pattern appears to be normal, you are ready to begin spray painting. If you have a split spray pattern, there are two possible causes - the air pressure is too high or the paint is too thin. If the pressure is too high, close the spreader adjustment valve slighltly. Recheck the pattern before beginning to paint. If the paint is too thin, open the fluid adjustment screw slightly and also close the spreader adjustment valve slightly to reduce the width of the spray. Recheck the spray pattern, adjusting until the correct pattern is reached. A fan spray pattern is caused by the air pressure being too low. Correct this by opening the spreader adjustment valve, then rechecking and adjusting until the normal pattern is reached. A crescent spray pattern is caused by a restriction through the wing ports. Correct this problem by cleaning the wing ports with solvent. Do not use a metal instrument to clean the wing ports.

When painting, position the gun approximately 8 inches away from the surface to be painted. Hold the gun 90 degrees to the work, as illustrated.

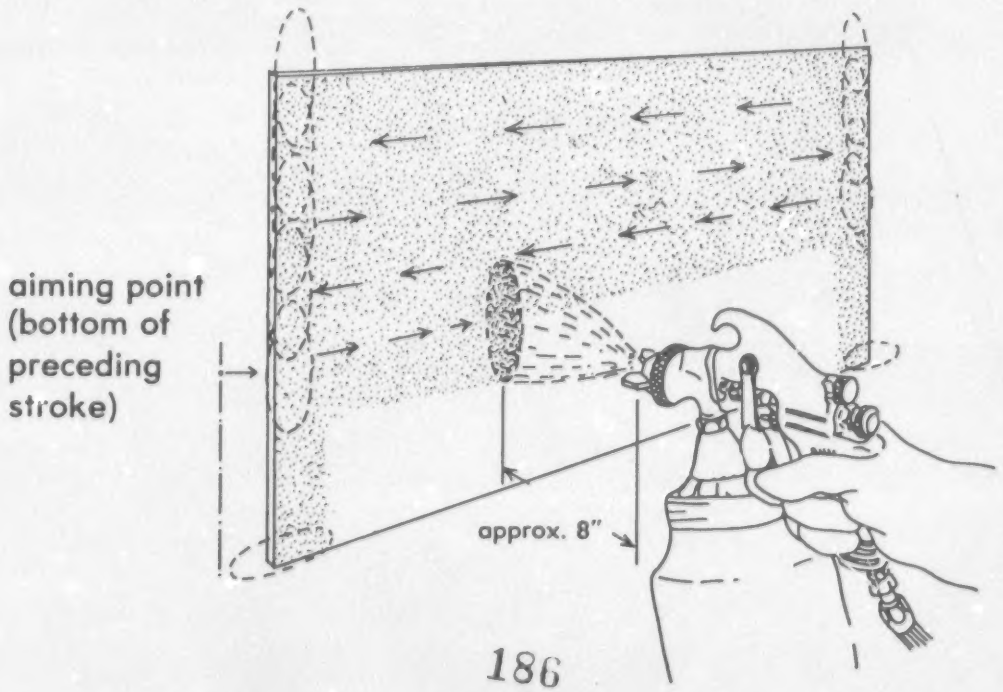


Angling the gun will cause an uneven paint coat and will result in sags and runs, as shown.

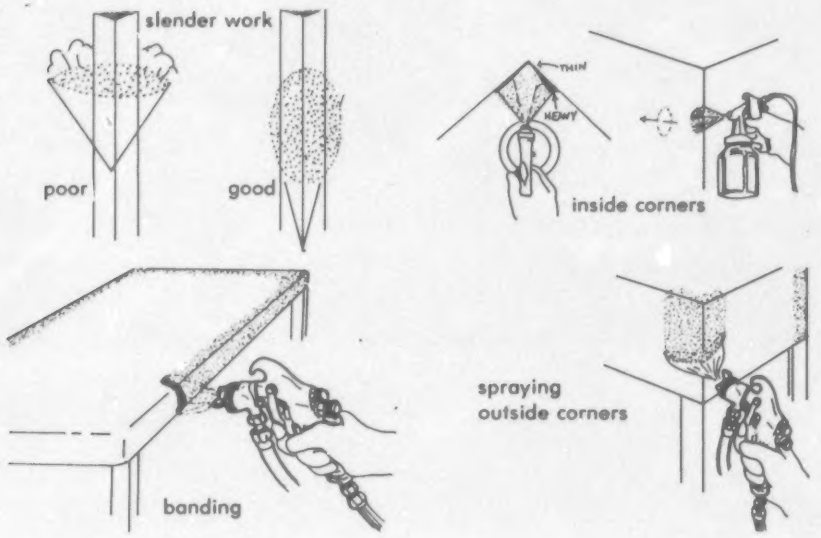
As you pull the trigger and move the gun forward, move the gun parallel to the surface being painted. If you swing the gun in an arc, the paint coat will be too light at either end and too heavy in the middle. The correct and incorrect techniques are shown in the following illustration.



When spray painting a large flat area, such as a panel, paint the edges first. Loosen the air cap and turn the wing ports 90 degrees, so that the oval of the pattern is horizontal instead of vertical. Make one pass down each edge. After painting the edges, turn the wing ports back to a vertical spray pattern and make the firt pass, starting at the top left of the panel. Each pass should begin with the gun aimed at a point 2 to 3 inches outside of the edge of the panel. Aim the gun so that the middle of the spray pattern is at the edge of the panel on the first pass. Pull the trigger all the way back and move the gun at a constant speed and constant distance from the surface all of the way across. Speed of travel will determine the thickness of the paint coat. Continue to the same distance beyond the panel and release the trigger. Move down and make the second pass from right to left. Aim the gun so that the middle of the spray pattern is at the bottom of the spray pattern from the previous pass. The same steps should be followed as on the previous pass - aim at a point 2 to 3 inches outside the edge of the panel, pull the trigger all of the way back, and move at a constant speed across the face of the panel until you are 2 to 3 inches beyond the panel and release the trigger. Continue this procedure, alternating left to right and right to left strokes until the panel is completed. These steps are depicted in the following illustration.



Unfortunately, not all surfaces which are spray painted can be painted this easily. There are, however, a few special techniques which will help in painting these places. These are illustrated in the following drawing.



For thin, vertical material, such as table legs, less overspray will occur if the wing ports are turned in such a way that the spray pattern is vertical. When painting inside corners, treat the corner as two separate panels. Directing the spray right into the corner causes a heavy coat of paint (which will run and sag) in the corner. If the object being painted has narrow edges, such as a table, a banding technique would be appropriate. Outside corners can be painted in the manner shown.

Always direct any overspray onto an unpainted area. If, for example, an outside corner were painted last, the overspray would fall on painted areas and would leave those areas with a "dusty" appearance. If you are painting a project, paint all of the edges first, then paint the large flat areas.

Be aware of overspray. The atomized droplets of paint which do not land on the object being painted will land on objects in the spray booth, will get drawn out into the exhaust system, etc. If spraying outside, a breeze will carry these droplets for a great distance. Make sure that vehicles are removed from the area, as they may wind up with an unwanted speckled paint job.

When finished painting, clean the gun thoroughly. If paint dries in the passages of the gun, it can render the gun nearly useless. To clean the gun, loosen the air cap two or three turns. Remove the paint cup. Positioning the spray gun over the cup, hold a loosely wadded cloth over the air cap and pull the trigger to force any remaining material back into the cup. Lay the gun aside, then empty the cup of all paint and clean it thoroughly. Next, fill the cup about half full of a solvent which will cut the paint in the gun. Reassemble the gun and spray the solvent through the gun. Disconnect the air supply. Remove the air cap and soak it in solvent to remove any dried paint. Use solvent to clean any paint from the outside of the gun. Reassemble the gun.

Common Problems When Spray Painting

Careful workmanship will eliminate most problems encountered while spray painting. For example, runs and sags, which are the most common problem for the beginning spray painter, are usually caused by the application of a paint coating that is too heavy. This can be caused from moving the gun too slowly or at an uneven rate of speed. When runs and sags occur, take a fine camel-hair brush and brush out the sag, then recoat the area. Sags may also be removed by slapping a piece of nylon hose against the sag. Pull the piece of hose away. This will remove the extra paint as the paint goes through the mesh of the hose and is removed when the piece of hose is removed. Recoat the area. If the paint dries, the sag will have be sanded down and refinished.

Poor surface preparation can cause problems as well. Painting over grease or oil will cause the paint surface to develop blisters as it dries. The blistered area will have to be sanded down and completely refinished. Poor surface preparation can also cause the surface of the paint to separate from the subsurface. The peeling area has to be refinished.

Shriveling or wrinkling of the surface can occur if you do not allow coats of enamel to dry adequately before spraying the next coat. The wrinkled area will need to be removed and refinished. This can also occur if lacquer is applied over enamel. Prevent the wrinkling by applying a sealer before applying the lacquer coat.

Rust areas under the finish can be caused by improper metal preparation or by water in the air lines. Rust area will need to be taken down to bare metal and treated with metal conditioner before refinishing. Moisture in the air lines can be prevented by putting moisture traps in the air lines and emptying them regularly.

Summary

When spray painting, follow all safety precautions, including wearing a respirator and appropriate clothing. Avoid the danger of explosion and fire. Prepare the surface for painting by washing with a solvent cleaner, following appropriate procedures for the type of surface, then using a metal conditioner to prevent rust. Select a primer-paint system appropriate for the environment of use, method of application, and cost involved. Follow the appropriate procedures for painting by preparing the paint, adjusting the gun, painting the surface, then cleaning the gun.

Credits

1. Automotive Refinishing Guide, Sherwin-Williams Company.

2. Conventional, Hot, and Airless Spray Equipment for Decorators and Maintenance Painters, The DeVilbiss Company.

3. Ditzler Repaint Manual, PPG Industries, Inc.

4. Heavy Duty Coating Systems, Cook Paint and Varnish Company.

5. Making the Most of the Spray Painting Method, The DeVilbiss Company (filmstrip).

6. The Selection of Paint, National Paint, Varnish and Lacquer Association.

UNIT - PAINTING

SHOP DEMONSTRATION #1: Spray Painting

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise of spray painting a shop project.

Tools Needed:

1. Spray painting unit
2. Respirator
3. Rubber gloves
4. Safety goggles
5. Wooden paint stirring paddle

Materials Needed:

1. One each - unpainted shop project
2. Appropriate paint
3. Compatible primer
4. Metal conditioner
5. Thinner or reducer
6. Solvent cleaner
7. Solvent to clean the spray gun
8. Paint strainers
9. Clean containers for holding paint
10. Clean cloths
11. Fine camel-hair brush or nylon hose

Procedure:

Step 1: Demonstrate proper metal preparation for spray painting.

a) Clean the surface with a solvent cleaner. Wash a small area at a time, then dry with clean cloths.
b) Use a metal conditioner. Wipe off any excess conditioner and wipe dry with clean cloths before priming.

Step 2: Demonstrate the procedures to follow when spray painting.

a) Spray a coat of primer on the project.
b) Stir the paint by agitating thoroughly, emptying the contents into a container, cleaning out the can with a small amount of thinner, then adding this to the paint.
c) Thin or reduce the paint.
d) Strain the paint.
e) Fill the gun, then adjust it.
   (1) Set air pressure at 30 to 40 pounds.
   (2) Hold a sheet of paper approximately 8 inches in front of the gun and briefly depress the trigger.
   (3) Examine the pattern and correct any problems.
f) Holding the gun approximately 8 inches from the surface and moving the gun parallel to the surface, begin painting.
   (1) Paint all edges first.

(2) Begin each pass at a point 2 to 3 inches beyond the edge of the surface, depressing the trigger, and moving at a constant rate of speed across the panel.
(3) Aim the first pass so that the middle of the pattern is at the top edge of the painted area. Move left to right.
(4) Continue the stroke to a point 2 to 3 inches beyond the edge, then release the trigger.
(5) Move down to make the second pass from right to left, aiming the gun so that the middle of the pattern is at the bottom of the previous pass.
(6) Continue this procedure, alternating left to right and right to left strokes until the project is painted.
(7) Use special techniques as needed.

g) Clean the gun.
(1) Loosen the air cap 2 or 3 turns.
(2) Remove the paint cup.
(3) Positioning the spray gun over the cup, hold a loosely wadded cloth over the air cap and pull the trigger to release any paint still in the gun back into the cup.
(4) Lay the gun aside.
(5) Empty the cup of all paint and clean it thoroughly.
(6) Fill the cup about half full of an appropriate solvent.
(7) Reassemble the gun and spray the solvent through the gun.
(8) Disconnect the air supply.
(9) Remove the air cap and soak it in solvent to remove any dried paint.
(10) Use solvent to clean the outisde of the gun.
(11) Reassemble the gun.

UNIT - PAINTING

SHOP EXERCISE #1: Spray Painting

Objective: At the end of this exercise, the student will be able to spray paint a shop project.

Tools Needed:

1. Spray painting unit
2. Respirator
3. Rubber gloves
4. Safety goggles
5. Wooden paint stirring paddle

Materials Needed:

1. One each - unpainted shop project
2. Appropriate paint
3. Compatible primer
4. Metal conditioner
5. Thinner or reducer
6. Solvent cleaner
7. Solvent to clean the spray gun
8. Paint strainers
9. Clean containers for holding paint
10. Clean cloths
11. Fine camel-hair brush or nylon hose

Procedure:

Step 1: Prepare the metal for spray painting.

a) Clean the surface with a solvent cleaner. Wash a small area at a time, then dry with clean cloths.
b) Use a metal conditioner. Wipe off any excess conditioner and wipe dry with clean cloths before priming.

Step 2: Spray paint the project.

a) Spray a coat of primer on the project.
b) Stir the paint by agitating thoroughly, emptying the contents into a container, cleaning out the can with a small amount of thinner, then adding this to the paint.
c) Thin or reduce the paint.
d) Strain the paint.
e) Fill the gun, then adjust it.
   (1) Set air pressure at 30 to 40 pounds.

(2) Hold a sheet of paper approximately 8 inches in front of the gun and briefly depress the trigger.
(3) Examine the pattern and correct any problems.

f) Holding the gun approximately 8 inches from the surface and moving the gun parallel to the surface, begin painting. (Refer to Figure 1.)
(1) Paint all edges first. (Refer to Figure 2.)
(2) Begin each pass at a point 2 to 3 inches beyond the edge of the surface, depressing the trigger, and moving at a constant rate of speed across the panel.
(3) Aim the first pass so that the middle of the pattern is at the top edge of the painted area. Move left to right.
(4) Continue the stroke to a point 2 to 3 inches beyond the edge, then release the trigger.
(5) Move down to make the second pass from right to left, aiming the gun so that the middle of the pattern is at the bottom of the previous pass.
(6) Continue this procedure, alternating left to right and right to left strokes until the project is painted.
(7) Use special techniques as needed.

g) Clean the gun.
(1) Loosen the air cap 2 or 3 turns.
(2) Remove the paint cup.
(3) Positioning the spray gun over the cup, hold a loosely wadded cloth over the air cap and pull the trigger to release any paint still in the gun back into the cup.
(4) Lay the gun aside.
(5) Empty the cup of all paint and clean it thoroughly.
(6) Fill the cup about half full of an appropriate solvent.
(7) Reassemble the gun and spray the solvent through the gun.
(8) Disconnect the air supply.
(9) Remove the air cap and soak it in solvent to remove any dried paint.

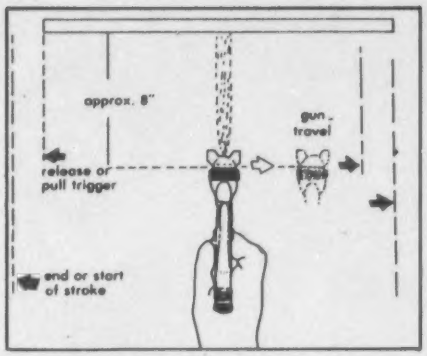


Figure 1

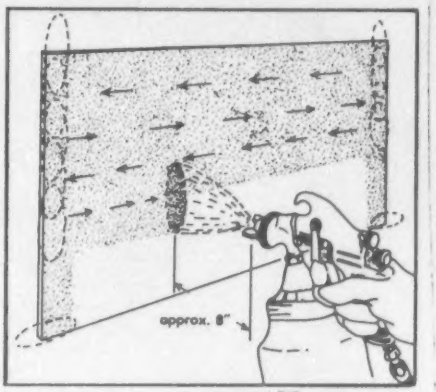


Figure 2

(10) Use solvent to clean the outside of the gun.
(11) Reassemble the gun.

UNIT - TOOL SHARPENING AND RECONDITIONING

Lesson 1: How do I sharpen or recondition wood chisels, plane irons, and center punches?

Objective: At the end of this lesson, the student will be able to sharpen or recondition wood chisels, plane irons, and center punches.

Study Questions:

1. **How do I set up the grinder for tool sharpening?**
2. **What is the procedure for sharpening wood chisels and plane irons?**
3. **How do I recondition a center punch?**

References:

1. Modern Agricultural Mechanics, Wakeman, Chapter 3.
2. Shopwork on the Farm, Jones, Chapter 7.
3. Transparency Masters
   a. TM-1: Setting Up the Grinder for Tool Reconditioning
   b. TM-2: Dressing the Grinding Wheel
   c. TM-3: Angles for Grinding Wood Chisels and Plane Irons
   d. TM-4: Reconditioning a Center Punch
4. Shop Demonstrations
   a. #1: Sharpening a Wood Chisel and a Plane Iron
   b. #2: Reconditioning a Center Punch
5. Shop Exercises
   a. #1: Sharpening a Wood Chisel or a Plane Iron
   b. #2: Reconditioning a Center Punch

UNIT - TOOL SHARPENING AND RECONDITIONING

Lesson 1: How do I sharpen or recondition wood chisels, plane irons, and center punches?

TEACHING PROCEDURES

A. Review

At the start of this unit, review with the class points learned in Animal Science - Agricultural Mechanics, especially:

1. Safe use of the grinder.
2. Preventing overheating when tool reconditioning.
3. Selection of stones and grinding wheels for tool reconditioning.

B. Motivation: Ask the students if they have ever tried to use tools that were not in good condition. Ask them what the results were.

C. Assignment

D. Supervised Study

E. Discussion

1. Show TM-1 and TM-2 to the students. Ask the students how to set up the grinder for tool reconditioning.

How do I set up the grinder for tool sharpening?

1) Set the explosion guard so that the opening is no more than 1/8-inch wide. (Refer to TM-1.)
2) Make sure that the shatterproof eyeshield is in the proper position.
3) Make sure all guards are in place.
4) Dress the grinding wheel to make sure there is a true surface to work from. (Refer to TM-2.)
   a) Always wear a dust mask and leather gloves when operating the wheel dresser.
   b) Move the tool rest out until you can place the star wheel dresser in position. The projections on the dresser provide leverage for the dresser while in use.
   c) Turn the grinder on and raise the handle of the dresser to force the star wheels into the rotating grinding wheel.
   d) Move the dresser from side to side, maintaining even pressure on the dresser. (If there is heavy sparking, the star wheels are being ground. Increase the pressure on the dresser.)
   e) Turn off the grinder and examine the grinding wheel. Make sure that any grooves are removed. Repeat the dressing as necessary.
5) Adjust the tool rest so that the opening between the guard and the wheel is no more than 1/8-inch. For general work, a level tool rest, set just below the center of the wheel, is best. Adjusting the tool rest at an angle will give support as grinding is done on a bevel.

2. Show TM-3 to the students. Ask the students to what angles wood chisels and plane irons should be ground and the procedures for reconditioning each one.

What is the procedure for sharpening wood chisels and plane irons?

1) The edge should be ground at an angle of 25 to 30 degrees. For hardwoods, the angle should be 25 degrees; for softer woods, the angle can be increased toward 30 degrees. The edge should also be 90 degrees to the shank. (Refer to TM-3.)
2) Procedures for sharpening:
   a) Check the edge of the tool to see if it is square. Using the grinder sparingly, square the edge as needed.
   b) With the grinder off and the wheel stopped, hold the tool flat on the tool rest and adjust the angle of the tool rest upward until the proper bevel will be reached. Make sure to adjust the tool rest so that the opening is no more than 1/8-inch.
   c) Turn the grinder on and move the tool from side to side, dipping frequently in water to maintain the temper. Keep firm pressure against the wheel.
   d) Continue grinding until the desired angle is reached across the face of the tool, until all nicks in the edge are removed, and until the dull edge is removed.
   e) Recheck the edge with a square to make sure that the edge is still square.
   f) Remove the wire edge caused by grinding by whetting on an oilstone.
      (1) Place a few drops of oil on the fine side of the oilstone.
      (2) Lay the tool flat on the oilstone, with the beveled edge up.
      (3) Push the tool forward and backward, putting pressure only on the forward stroke. Use strokes that use the full length of the stone.
      (4) A few strokes will either remove the wire edge or turn it to the beveled side. If the wire edge turns, turn the tool over and use a few light strokes to turn the wire edge again. Turn the tool over and repeat the whetting.
3) If the cutting surface is not nicked, plane irons and wood chisels can be sharpened on the coarse side of the oilstone, then whetted on the fine side, without using the grinder.
4) The head of a wood chisel may need to be redressed if it is mushroomed. Redress by grinding down the mushroomed area to a uniform appearance, with the area to be struck smaller than the diameter of the handle of the chisel.

3. Show TM-4 to the students. Ask the students to what angle a center punch should be ground and the procedures for reconditioning.

How do I recondition a center punch?

1) Center punches are ground at a 60-degree angle. (Refer to TM-4.)
2) Set the tool rest level, just lower than the center of the grinding wheel, with an opening of no more than 1/8-inch.

3) Lay the punch flat on the tool rest, with the center of the punch at a 30-degree angle to the grinding surface.
4) Turn the grinder on and slowly rotate the punch maintaining a firm pressure against the grinding wheel.
5) Dip the point of the punch in water frequently to keep from burning the tip of the punch.
6) Check the tip of the punch to make sure that the point is in the center of the shank of the punch.
7) Recondition the head of the punch if necessary.

F. Other Activities

Shop Demonstrations
#1 - Sharpening a Wood Chisel and a Plane Iron
#2 - Reconditioning a Center Punch

Shop Exercises
#1 - Sharpening a Wood Chisel or a Plane Iron (The student will sharpen either a wood chisel or a plane iron.)
#2 - Reconditioning a Center Punch

G. Summary

When reconditioning wood chisels, plane irons, and center punches, a student should:

1. Set up the explosion guard and tool rest within 1/8-inch of the grinding wheel.
2. Dress the grinding wheel as needed to obtain a true surface.
3. Sharpen wood chisels and plane irons at an angle of 25 to 30 degrees.
4. Grind center punch points at an angle of 60 degrees.
5. Recondition the heads of punches and chisels when needed.

H. Answers to Evaluation

1. F
2. T
3. T
4. F
5. T
6. F
7. T
8. T

UNIT - TOOL SHARPENING AND RECONDITIONING

Lesson 1: How do I sharpen or recondition wood chisels, plane irons, and center punches?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. Large volumes of sparks should be given off when using the star wheel dresser.

T F 2. If the edge of a plane iron is not nicked, it can be sharpened on the oilstone without using the grinder.

T F 3. The tool rest is in proper adjustment when the distance between the tool rest and the grinding wheel is no more than 1/8-inch.

T F 4. The tip of a center punch should be ground at an angle of 40 degrees.

T F 5. Plane irons and wood chisels should be whetted on an oilstone to remove the wire edge from grinding.

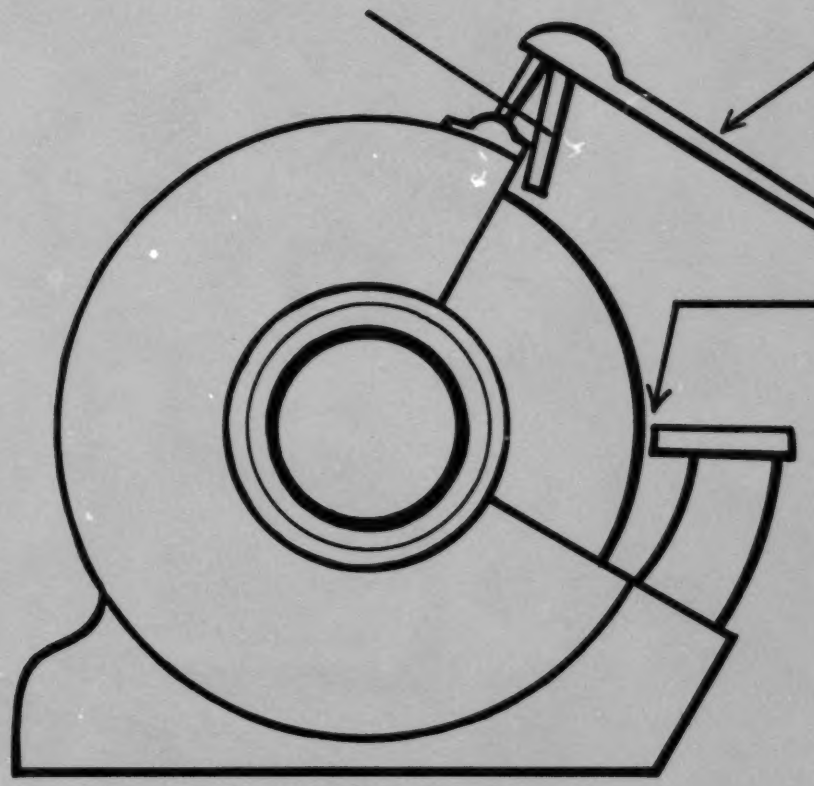
T F 6. The cutting edge of a wood chisel should be ground at 60 degrees.

T F 7. Dipping the center punch in water frequently when grinding helps to prevent burning of the tip.

T F 8. If the head of a center punch is mushroomed, it should be reconditioned.

Setting Up the Grinder for Tool Reconditioning

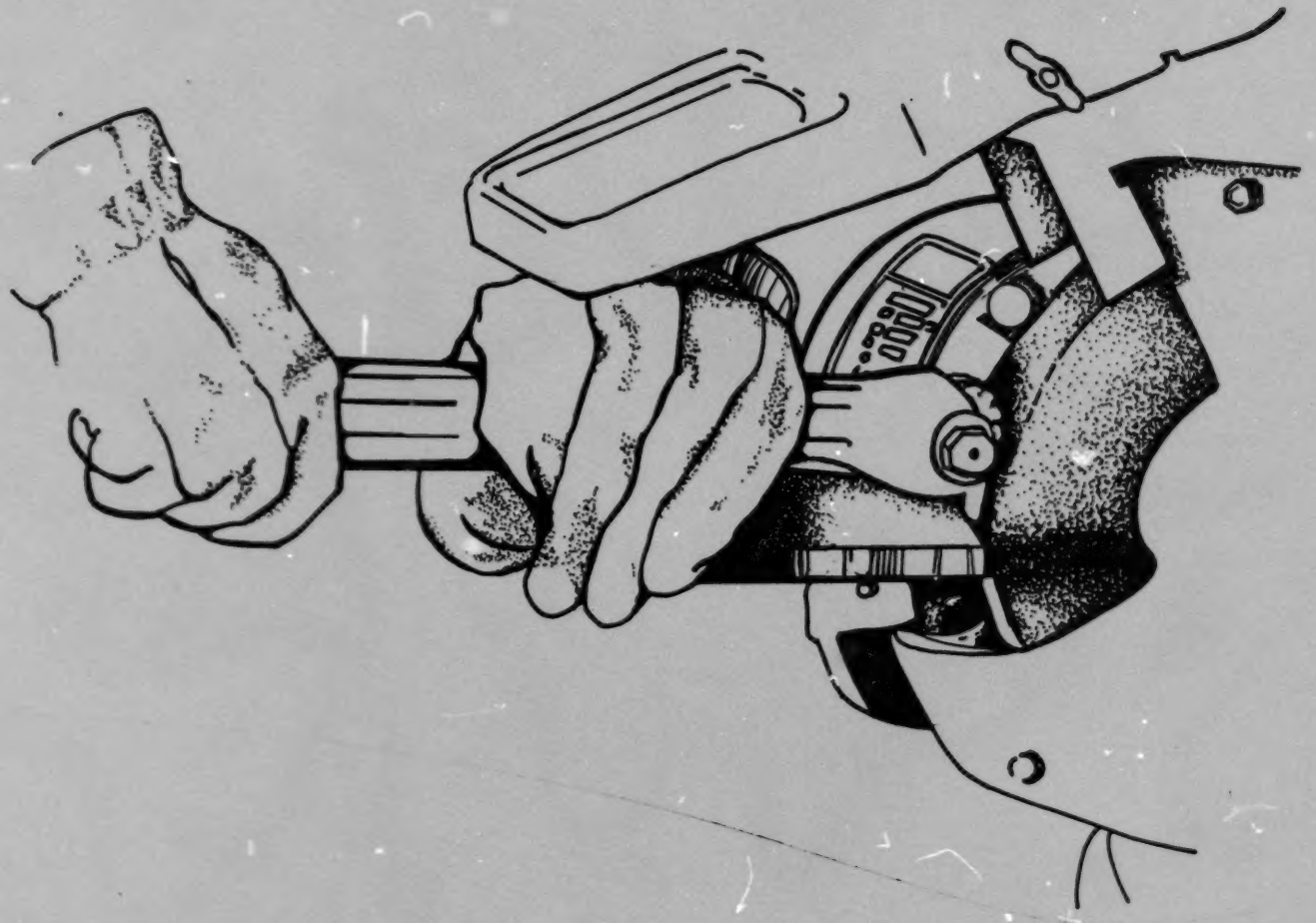
No more than 1/8-in. opening between the explosion guard and the grinding wheel



Shatterproof eyeshield

No more than 1/8-in. opening between the tool rest and the grinding wheel

Dressing the Grinding Wheel

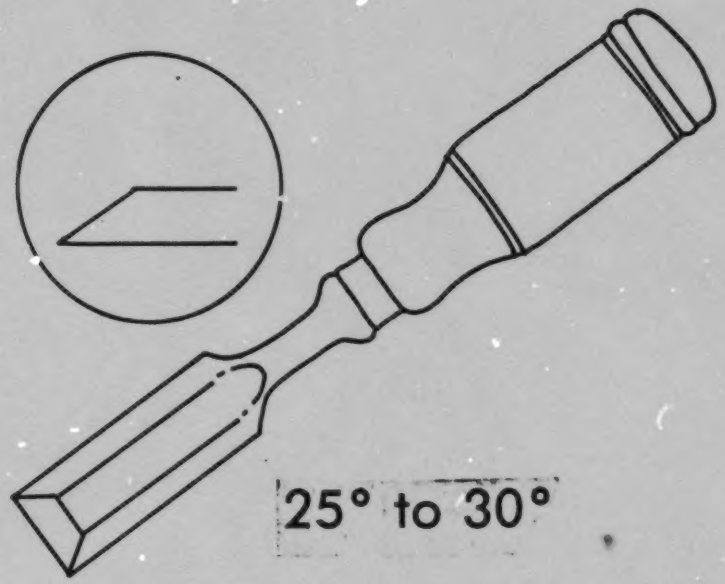


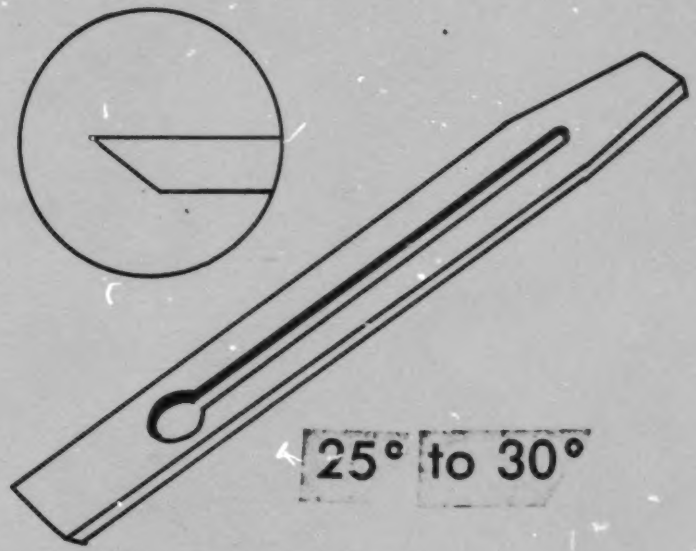
201

202

TM-2

Angles for Grinding Wood Chisels and Plane Irons



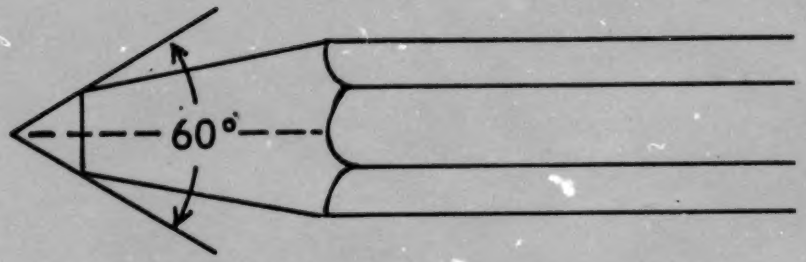


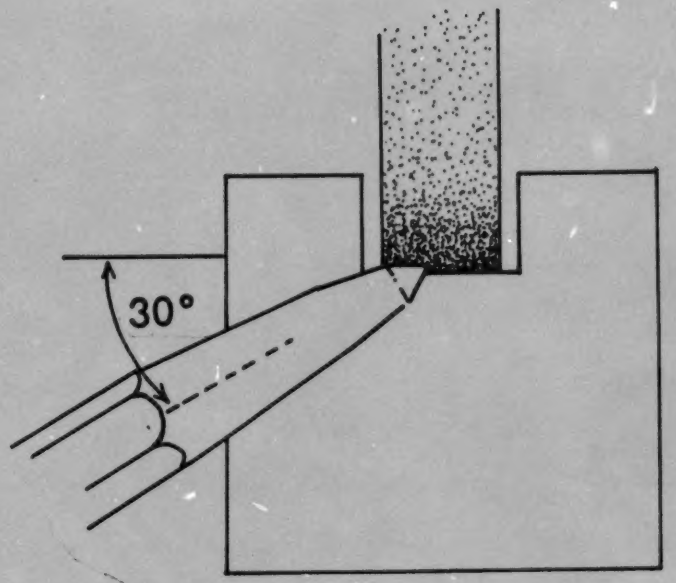
203 wood chisel

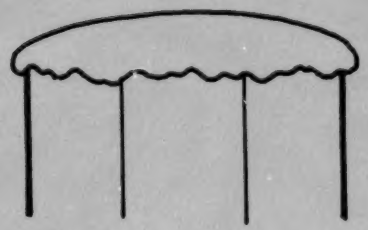
plane iron 204

TM-3

Reconditioning a Center Punch







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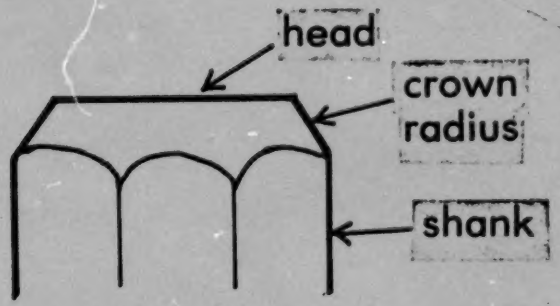


correct

UNIT - TOOL SHARPENING AND RECONDITIONING

SHOP DEMONSTRATION #1: Sharpening a Wood Chisel and a Plane Iron

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise of sharpening a wood chisel or a plane iron.

Tools Needed:

1. Bench grinder, properly shielded
2. Safety glasses
3. Leather gloves
4. Star wheel dresser
5. Wrenches for adjusting the tool rest, explosion guard, and eyeshield
6. Dust mask
7. Oilstone

Materials Needed:

1. One each - dull wood chisel
2. One each - dull plane iron
3. Oil for the oilstone - SAE 10 or a mixture of motor oil and kerosene (If a new stone is purchased, follow the manufacturer's recommendations as to the oil to use.)

Procedure:

Step 1: (Optional) Demonstrate a review exercise in tool reconditioning, such as twist drill sharpening, for the students to complete prior to beginning sharpening wood chisels and plane irons. (See the Agricultural Mechanics Unit for Animal Science, Demonstration #2 for the twist drill sharpening demonstration.)

Step 2: Demonstrate how to set the tool rest, explosion guard, and eyeshield for tool conditioning.

Step 3: Demonstrate how to dress a grinding wheel using the star wheel dresser.

a) Always wear a dust mask and leather gloves when operating the wheel dresser.
b) Move the tool rest out until you can place the star wheel dresser in position. The projections on the dresser provide leverage for the dresser while in use.
c) Turn the grinder on and raise the handle of the dresser to force the star wheels into the rotating grinding wheel.
d) Move the dresser from side to side, maintaining even pressure on the dresser. (If there is heavy sparking, the star wheels are being ground. Increase the pressure on the dresser.)
e) Turn off the grinder and examine the grinding wheel. Make sure that any grooves are removed. Repeat the dressing as necessary.

Step 4: Demonstrate sharpening a wood chisel.

a) Check the edge of the chisel to see if it is square. Using the grinder sparingly, square the edge as needed.

b) With the grinder off and the wheel stopped, hold the chisel flat on the tool rest and adjust the angle of the tool rest upward until the proper bevel will be reached. Make sure to adjust the tool rest so that the opening is no more than 1/8-inch.

c) Turn the grinder on and move the chisel from side to side, dipping frequently in water to maintain the temper. Keep firm pressure against the wheel.

d) Continue grinding until the desired angle of 25 to 30 degrees is reached across the face of the chisel, until all nicks in the edge are removed, and until the dull edge is removed.

e) Recheck the edge with a square to make sure that the edge is still square.

f) Remove the wire edge caused by grinding by whetting on an oilstone.
   (1) Place a few drops of oil on the fine side of the oilstone.
   (2) Lay the chisel flat on the oilstone, with the beveled edge up.
   (3) Push the chisel forward and backward, putting pressure only on the forward stroke. Use strokes that use the full length of the stone.
   (4) A few strokes will either remove the wire edge or turn it to the beveled side. If the wire edge turns, turn the chisel over and use a few light strokes to turn the wire edge again. Turn the chisel over and repeat the whetting.

g) Dress the head of the chisel if needed.

Step 5: Demonstrate sharpening a plane iron.

a) Check the edge of the plane iron to see if it is square. Using the grinder sparingly, square the edge as needed.

b) With the grinder off and the wheel stopped, hold the plane iron flat on the tool rest and adjust the angle of the tool rest upward until the proper bevel will be reached. Make sure to adjust the tool rest so that the opening is no more than 1/8-inch.

c) Turn the grinder on and move the plane iron from side to side, dipping frequently in water to maintain the temper. Keep firm pressure against the wheel.

d) Continue grinding until the desired angle of 25 to 30 degrees is reached across the face of the plane iron, until all nicks in the edge are removed, and until the dull edge is removed.

e) Recheck the edge with a square to make sure that the edge is still square.

f) Remove the wire edge caused by grinding by whetting on an oilstone.
   (1) Place a few drops of oil on the fine side of the oilstone.
   (2) Lay the plane iron flat on the oilstone, with the beveled edge up.
   (3) Push the plane iron forward and backward, putting pressure only on the forward stroke. Use strokes that use the full length of the stone.
   (4) A few strokes will either remove the wire edge or turn it to the beveled side. If the wire edge turns, turn the plane iron over and use a few light strokes to turn the wire edge again. Turn the plane iron over and repeat the whetting.

UNIT - TOOL SHARPENING AND RECONDITIONING

SHOP EXERCISE #1: Sharpening a Wood Chisel or a Plane Iron

Objective: At the end of this exercise, the student should be able to sharpen a wood chisel or a plane iron.

Tools Needed:

1. Bench grinder, properly shielded
2. Safety glasses
3. Leather gloves
4. Star wheel dresser
5. Wrenches for adjusting the tool rest, explosion guard, and eyeshield
6. Dust mask
7. Oilstone

Materials Needed:

1. One each - dull wood chisel
2. One each - dull plane iron
3. Oil for the oilstone - SAE 10 or a mixture of motor oil and kerosene (If a new stone is purchased, follow the manufacturer's recommendations as to the oil to use.)

Procedure:

Step 1: Before starting to sharpen a wood chisel or a plane iron, it may be helpful to practice reconditioning other tools that you studied last year. Sharpening a twist drill may be especially helpful. (You may wish to review Exercise #2 in Tool Sharpening and Reconditioning in the Agricultural Mechanics Unit for Animal Science.)

Step 2: Set the tool rest, explosion guard, and eyeshield for tool conditioning. (Refer to Figure 1.)

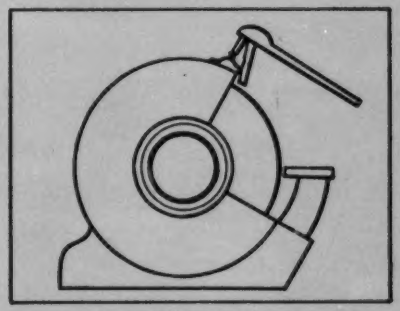


Figure 1

Step 3: Dress a grinding wheel using the star wheel dresser.

a) Always wear a dust mask and leather gloves when operating the wheel dresser.
b) Move the tool rest out until you can place the star wheel dresser in position. The projections on the

dresser provide leverage for the dresser while in use. (Refer to Figure 2.)

c) Turn the grinder on and raise the handle of the dresser to force the star wheels into the rotating grinding wheel.

d) Move the dresser from side to side, maintaining even pressure on the dresser. (If there is heavy sparking, the star wheels are being ground. Increase the pressure on the dresser.)

e) Turn off the grinder and examine the grinding wheel. Make sure that any grooves are removed. Repeat the dressing as necessary.

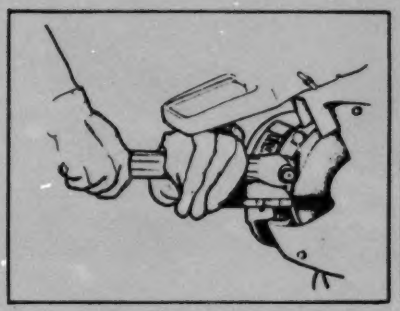


Figure 2

Step 4: Sharpen a wood chisel.

a) Check the edge of the chisel to see if it is square. Using the grinder sparingly, square the edge as needed.

b) With the grinder off and the wheel stopped, hold the chisel flat on the tool rest and adjust the angle of the tool rest upward until the proper bevel will be reached. Make sure to adjust the tool rest so that the opening is no more than 1/8-inch.

c) Turn the grinder on and move the chisel from side to side, dipping frequently in water to maintain the temper. Keep firm pressure against the wheel.

d) Continue grinding until the desired angle of 25 to 30 degrees is reached across the face of the chisel, until all nicks in the edge are removed, and until the dull edge is removed. (Refer to Figure 3.)

e) Recheck the edge with a square to make sure that the edge is still square.

f) Remove the wire edge caused by grinding by whetting on an oilstone.

(1) Place a few drops of oil on the fine side of the oilstone.

(2) Lay the chisel flat on the oilstone, with the beveled edge up.

(3) Push the chisel forward and backward, putting pressure only on the forward stroke. Use strokes that use the full length of the stone.

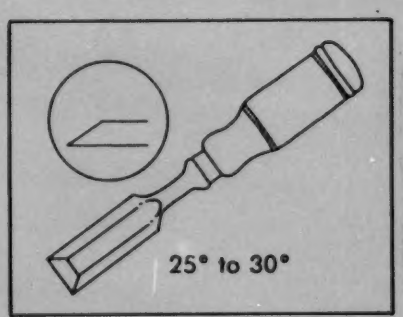


Figure 3

(4) A few strokes will either remove the wire edge or turn it to the beveled side. If the wire edge turns, turn the chisel over and use a few light strokes to turn the wire edge again. Turn the chisel over and repeat the whetting.

g) Dress the head of the chisel if needed.

Step 5: Sharpen a plane iron.

a) Check the edge of the plane iron to see if it is square. Using the grinder sparingly, square the edge as needed.

b) With the grinder off and the wheel stopped, hold the plane iron flat on the tool rest and adjust the angle of the tool rest upward until the proper bevel will be reached. Make sure to adjust the tool rest so that the opening is no more than 1/8-inch.

c) Turn the grinder on and move the plane iron from side to side, dipping frequently in water to maintain the temper. Keep firm pressure against the wheel.

d) Continue grinding until the desired angle of 25 to 30 degrees is reached across the face of the plane iron, until all nicks in the edge are removed, and until the dull edge is removed. (Refer to Figure 4.)

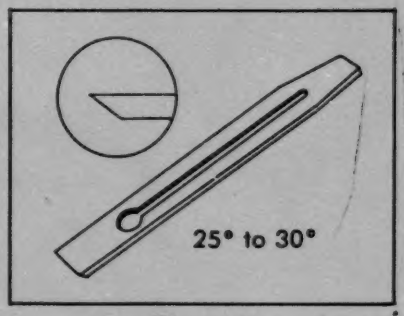


Figure 4

e) Recheck the edge with a square to make sure that the edge is still square.

f) Remove the wire edge caused by grinding by whetting on an oilstone.

(1) Place a few drops of oil on the fine side of the oilstone.

(2) Lay the plane iron flat on the oilstone, with the beveled edge up.

(3) Push the plane iron forward and backward, putting pressure only on the forward stroke. Use strokes that use the full length of the stone.

(4) A few strokes will either remove the wire edge or turn it to the beveled side. If the wire edge turns, turn the plane iron over and use a few light strokes to turn the wire edge again. Turn the plane iron over and repeat the whetting.

UNIT - TOOL SHARPENING AND RECONDITIONING

SHOP DEMONSTRATION #2: Reconditioning a Center Punch

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise of reconditioning a center punch.

Tools Needed:

1. Bench grinder, properly shielded
2. Safety glasses
3. Leather gloves
4. Star wheel dresser
5. Wrenches for adjusting the tool rest, explosion guard, and eyeshield
6. Dust mask
7. Oilstone

Materials Needed:

1. One each - center punch

Procedure:

Step 1: Demonstrate how to set the tool rest, explosion guard, and eyeshield for reconditioning a center punch.

Step 2: Demonstrate how to dress a grinding wheel using the star wheel dresser.

a) Always wear a dust mask and leather gloves when operating the wheel dresser.
b) Move the tool rest out until you can place the star wheel dresser in position. The projections on the dresser provide leverage for the dresser while in use.
c) Turn the grinder on and raise the handle of the dresser to force the star wheels into the rotating grinding wheel.
d) Move the dresser from side to side, maintaining even pressure on the dresser. (If there is heavy sparking, the star wheels are being ground. Increase the pressure on the dresser.)
e) Turn off the grinder and examine the grinding wheel. Make sure that any grooves are removed. Repeat the dressing as necessary.

Step 3: Demonstrate how to recondition a center punch.

a) Set the tool rest level, just below the center of the grinding wheel, with an opening less than 1/8-inch wide.
b) Lay the punch flat on the tool rest, with the center of the punch at a 30-degree angle to the grinding surface.
c) Turn the grinder on and slowly rotate the punch maintaining a firm pressure against the grinding wheel.
d) Dip the point of the punch in water frequently to keep from burning the tip of the punch.
e) Check the tip of the punch to make sure that the point is in the center of the shaft of the punch.
f) Recondition the head of the punch by grinding so that the area to be struck is smaller than the diameter of the shank.

UNIT - TOOL SHARPENING AND RECONDITIONING

SHOP EXERCISE #2: Reconditioning a Center Punch

Objective: At the end of this demonstration, the student should be able to recondition a center punch.

Tools Needed:

1. Bench grinder, properly shielded
2. Safety glasses
3. Leather gloves
4. Star wheel dresser
5. Wrenches for adjusting the tool rest, explosion guard, and eyeshield
6. Dust mask
7. Oilstone

Materials Needed:

1. One each - center punch

Procedure:

Step 1: Set the tool rest, explosion guard, and eyeshield for reconditioning a center punch. (Refer to Figure 1.)

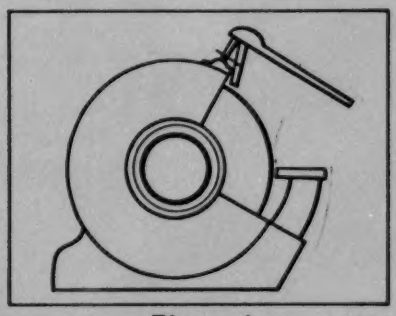


Figure 1

Step 2: Dress a grinding wheel using the star wheel dresser.

a) Always wear a dust mask and leather gloves when operating the wheel dresser.
b) Move the tool rest out until you can place the star wheel dresser in position. The projections on the dresser provide leverage for the dresser while in use. (Refer to Figure 2.)
c) Turn the grinder on and raise the handle of the dresser to force the star wheels into the rotating grinding wheel.
d) Move the dresser from side to side, maintaining even pressure on the dresser. (If there is heavy sparking, the star wheels are being ground. Increase the pressure on the dresser.)
e) Turn off the grinder and examine the grinding wheel. Make sure that any

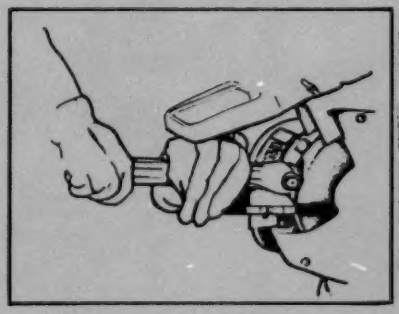


Figure 2

grooves are removed. Repeat the dressing as necessary.

Step 3: Recondition a center punch.

a) Set the tool rest level, just below the center of the grinding wheel, with an opening less than 1/8-inch wide.
b) Lay the punch flat on the tool rest, with the center of the punch at a 30-degree angle to the grinding surface. (Refer to Figure 3.)
c) Turn the grinder on and slowly rotate the punch maintaining a firm pressure against the grinding wheel.
d) Dip the point of the punch in water frequently to keep from burning the tip of the punch.
e) Check the tip of the punch to make sure that the point is in the center of the shaft of the punch.
f) Recondition the head of the punch by grinding so that the area to be struck is smaller than the diameter of the shank. (Refer to Figure 4.)

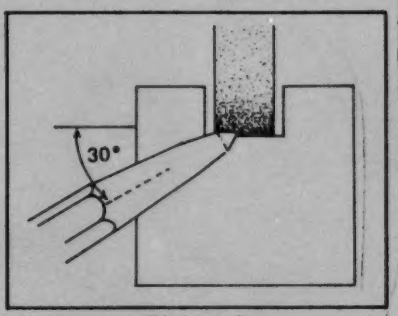


Figure 3

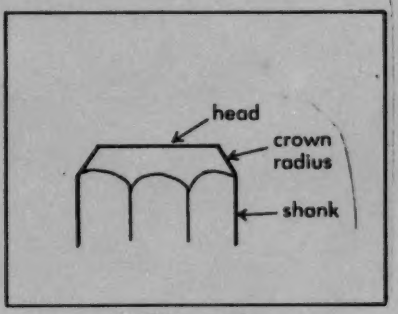


Figure 4

UNIT - TOOL SHARPENING AND RECONDITIONING

Lesson 2: How do I sharpen a chain saw?

Objective: At the end of this lesson, the student will be able to sharpen a chain saw.

Study Questions:

1. **Why is it important to keep the chain sharp?**
2. **What will affect how often the chain must be sharpened?**
3. **What steps do I follow to sharpen the chain?**
4. **How do I gauge the depth on the chain?**
5. **How do I adjust the chain tension?**

References:

1. Transparency Masters
   a. TM-5: Types of Cutters
   b. TM-6: Parts of a Cutter
   c. TM-7: Parts of a Cutter - Key
   d. TM-8: Chain Filing Equipment
   e. TM-9: Chain Filing Angle
   f. TM-10: Using the File Guide
   g. TM-11: Proper Chain Tension
2. Handout
   a. HO-1: Sharpening a Chain Saw
3. Shop Demonstration
   a. #3: Sharpening a Chain Saw
4. Shop Exercise
   a. #3: Sharpening a Chain Saw

UNIT - TOOL SHARPENING AND RECONDITIONING

Lesson 2: How do I sharpen a chain saw?

TEACHING PROCEDURES

A. Review

B. Motivation: Ask the students how many of them have used a chain saw with a dull chain. Ask the students who have had this experience to describe it.

C. Assignment: Have the students read HO-1.

D. Supervised Study

E. Discussion

1. Ask the students why it is important to keep the chain sharp.

Why is it important to keep the chain sharp?

1) A sharp chain will:
   a) Cut faster.
   b) Cut smoother.
   c) Reduce operator fatigue.
   d) Reduce wear and tear on the bar and sprocket.
   e) Reduce noise.

2. Ask the students what will affect how often the chain must be sharpened.

What will affect how often the chain must be sharpened?

1) Type of wood being cut.
2) How often the saw is used.
3) The working conditions.

3. Show TM-5 to the students. Ask the students to identify the types of cutters used in chain saws. Show TM-6 to the students. Ask the students to identify the parts of a cutter. Use TM-7 as an overlay to insure that the students have correctly identified each part. Show TM-8 to the students. Ask the students to identify the tools used in chain filing. Ask the students to identify the steps in filing the cutters. Show TM-9 to reinforce the correct filing angle.

What steps do I follow to sharpen the chain?

1) Types of cutters (Refer to TM-5.)
   a) Chipper
   b) Chisel
2) Parts of a cutter (Refer to TM-6 and TM-7.)
   a) Side plate
   b) Top plate
   c) Cutting edge

d) Gullet
e) Depth gauge
f) Rivet hole
g) Toe
h) Heel

3) Chain filing equipment (Refer to TM-8.)
   a) Full round file and holder
   b) File guide

4) Filing the cutters.
   a) Wear safety goggles and leather gloves for protection.
   b) Disconnect the spark plug wire and ground it to the engine block.
   c) Place the file in one of the cutters holding the file at 35 degrees to the bar (for chipper type chains) and keeping the file sharpening angle marks on the file holder parallel to the bar. (Refer to TM-9.)
   d) File from the inside out, keeping the file level.
   e) Give each cutter two strokes.
   f) Move to the next cutter on the same side and repeat the process.
   g) Using a gloved hand, rotate the chain as needed until all of the cutters on that side are sharpened.
   h) Turn the saw around and sharpen all of the cutters on the other side.
   i) Reattach the spark plug wire to the spark plug.

4. Ask the students how often the depth gauges should be checked. Show TM-10 to the student. Ask the students how to use the file guide. Ask the students how to gauge the depth of the chain.

How do I gauge the depth on the chain?

1) For this process, the spark plug wire should be disconnected and grounded to the engine block.
2) Check the depth gauges every third or fourth sharpening.
3) Use the file guide to check the depth gauges. (Refer to TM-10.)
4) If the top of the depth gauge extends above the file guide, file off the part above the guide with a flat file.
5) Round off the front corner of the depth gauge to keep it from dragging. Tilt the file guide upward to protect the sharpened cutter while performing this operation.
6) Repeat this process until all depth gauges have been checked and worked.
7) Reattach the spark plug wire.

5. Show TM-11 to the students. Ask the students how to adjust the tension on the chain.

How do I adjust the chain tension?

1) Always wear a leather glove to protect the hand which handles the chain.
2) Disconnect the spark plug wire and ground it to the engine block.
3) Loosen the bar nuts. (Refer to TM-11.)

4) Adjust the chain tension screw in or out until the chain just touches the bottom rails of the bar. Pull up on the top of the chain to make sure it will not come up out of the groove.
5) Oil the chain, then pull the chain around the bar by hand. Make sure that the chain is still in adjustment.
6) Hold the tip of the bar up as high as it will go and tighten the bar nuts.
7) Pull the chain around the bar again and make sure it moves freely.
8) Reconnect the spark plug wire to the spark plug.

F. Other Activities

Shop Demonstration
#3 - Sharpening a Chain Saw

Shop Exercise
#3 - Sharpening a Chain Saw

G. Summary

When sharpening a chain saw, a student should:

1. Sharpen the chain as often as necessary, depending on the type of wood being cut, how often the saw is used, and the working conditions.
2. Follow the proper steps and safety procedures when filing the cutters.
3. Check the depth gauges every third or fourth sharpening and file down as needed.
4. Adjust the chain tension as needed.

H. Answers to Evaluation

1. T
2. F
3. T
4. F
5. T
6. T
7. T

UNIT - TOOL SHARPENING AND RECONDITIONING

Lesson 2: How do I sharpen a chain saw?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. If the chain saw is being used to cut a hardwood like oak, it will get dull faster than if a softwood like pine were being cut.

T F 2. A half-round file is the type to use when filing cutters.

T F 3. A chipper type chain should be filed at an angle of 35 degrees.

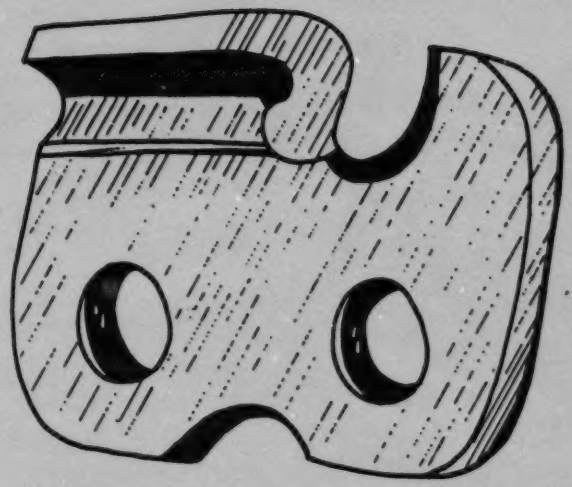
T F 4. Depth gauges should be filed down every time the chain is sharpened.

T F 5. The chain is in proper adjustment when the chain just touches the bottom rails of the bar.

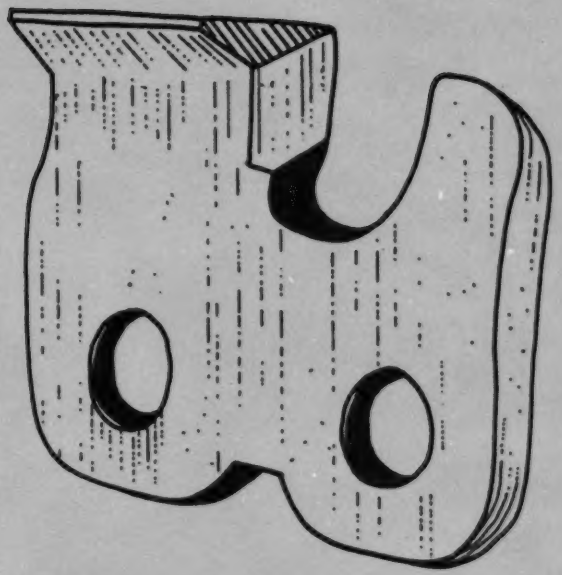
T F 6. When sharpening the saw, the spark plug wire should be disconnected and grounded to the engine block to prevent accidental starting of the engine.

T F 7. If the depth gauges are filed down, the front corners of the depth gauges should be rounded off to keep them from dragging.

Types of Cutters

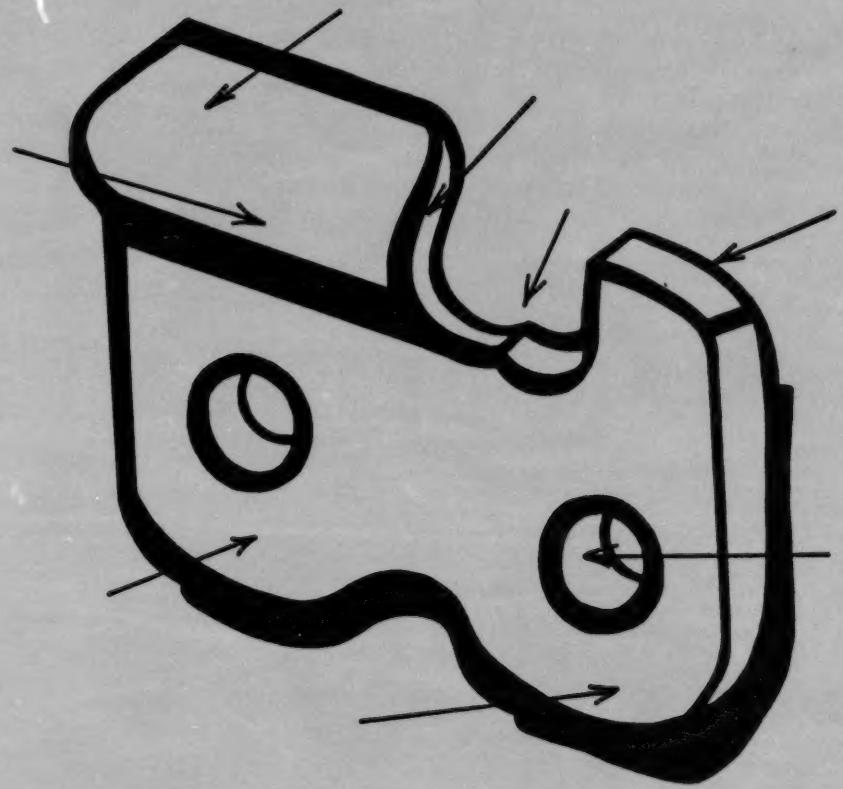


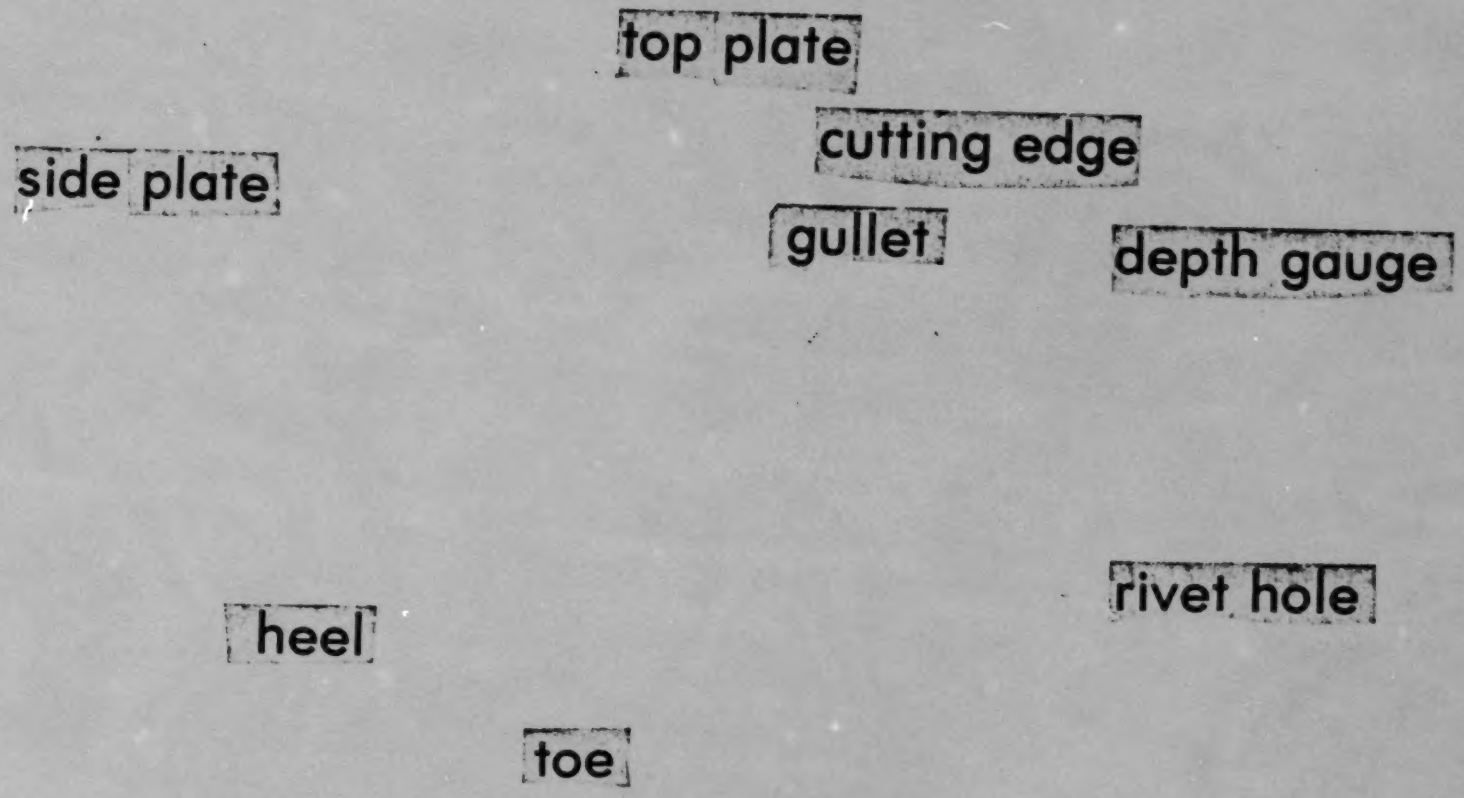
Chipper



Chisel

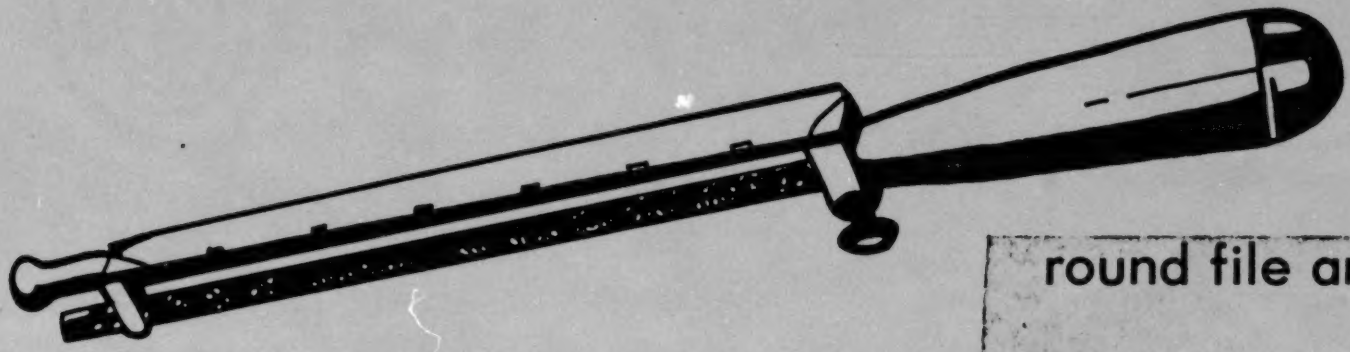
Parts of a Cutter



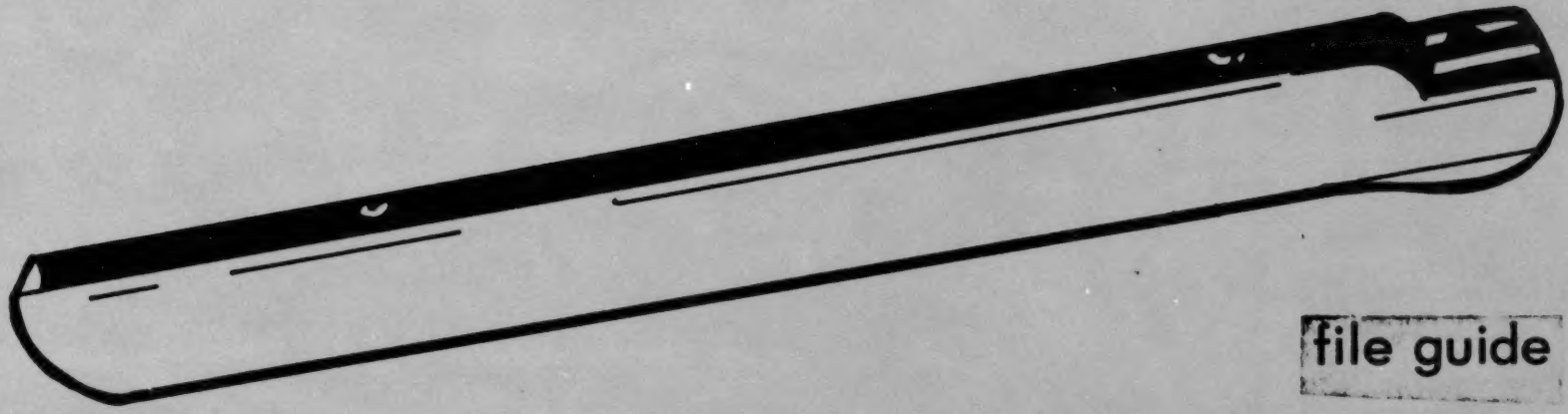

top plate
cutting edge
side plate
gullet
depth gauge
rivet hole
heel
toe

TM-7 Key

Chain Filing Equipment



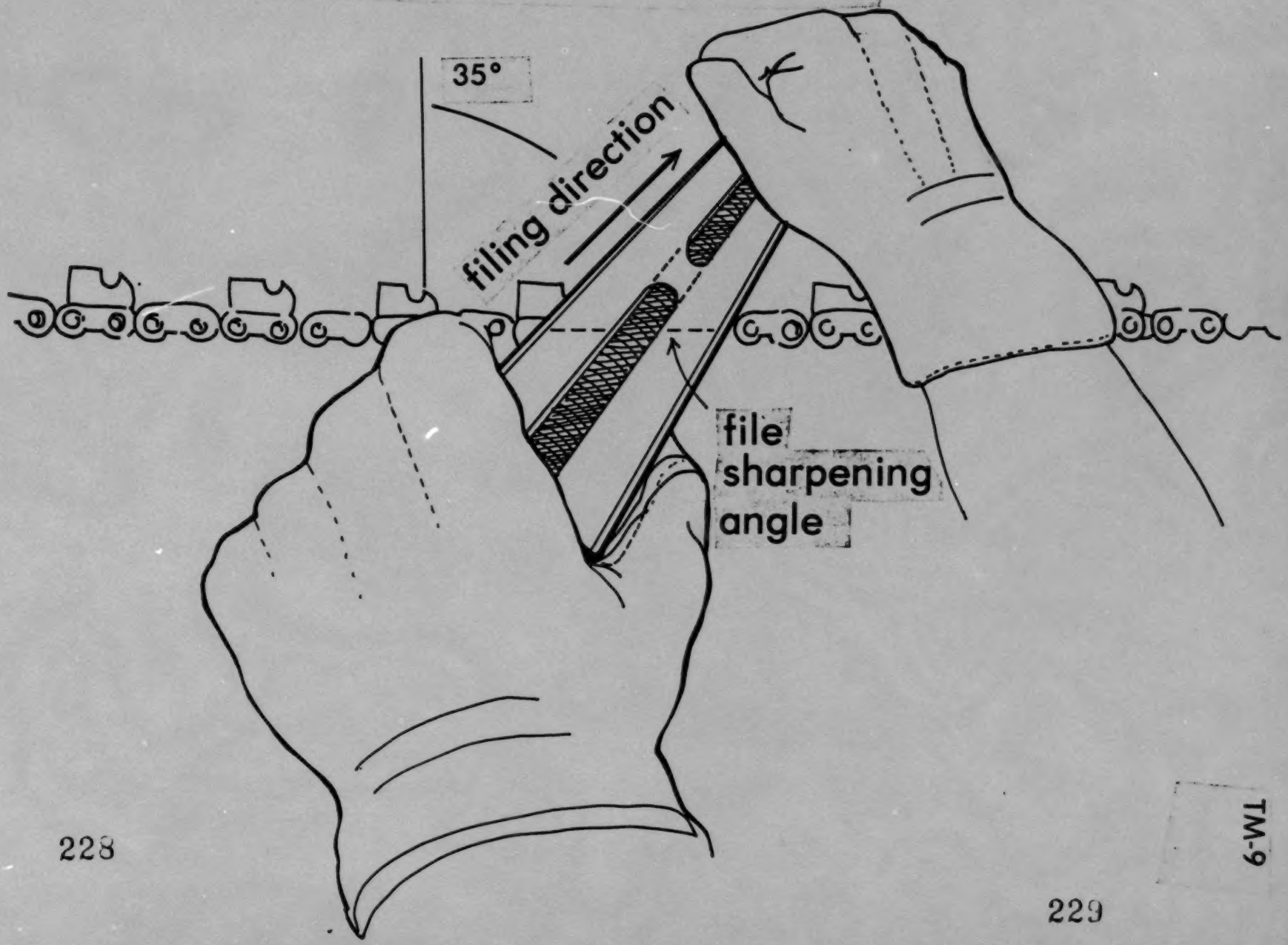
round file and holder



file guide

TM-8

Chain Filing Angle



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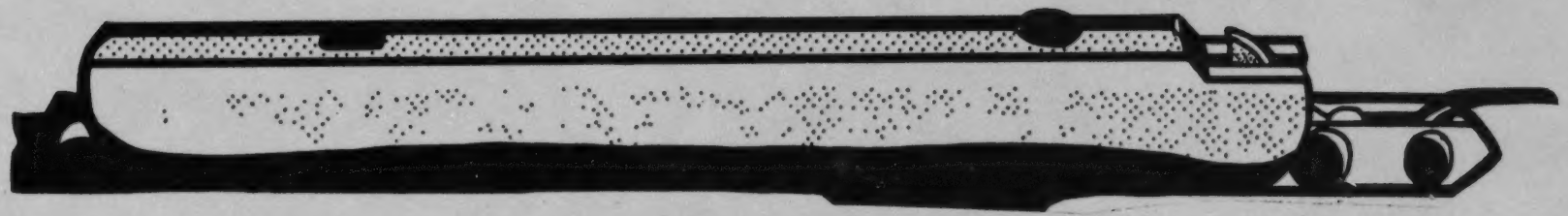
229

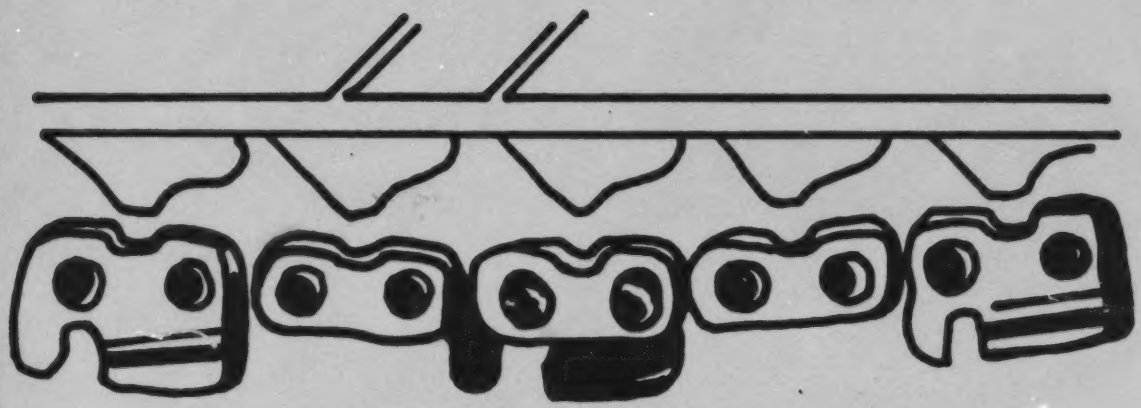
TM-9

Using the File Guide



TM-10

Proper Chain Tension



incorrect

correct

TM-11

SHARPENING A CHAIN SAW

Why Keep the Chain Sharp?

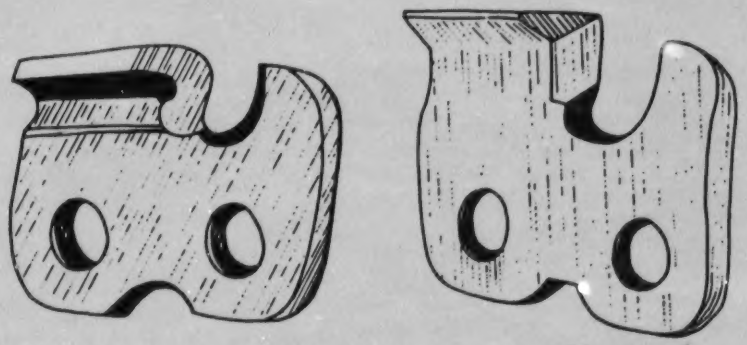
A chain saw, just like any other cutting tool, is safest when it is sharp. A dull chain will cost the operator time and effort. If the chain is sharp, it will not only cut faster, but also cuts smoother. The operator using a dull chain will become tired faster, because more force will be required to do the cutting. This extra force will also cause more wear and tear to the bar and sprocket. Another big plus for operators using sharp chains is that the noise from the saw will be reduced.

How Often to Sharpen the Chain

The obvious answer to the question "How often should I sharpen the chain for my chain saw?" is to sharpen it whenever it is dull. The chain will become dull at varying speeds depending on the type of wood being cut, how often the saw is used, and the working conditions. For example, the chain will become dull more quickly if hardwoods like oak or maple are being sawn than if softwoods like pine are being sawn. The chain will have to be sharpened more frequently if the saw is used a great deal. The chain will also become dull more quickly if the tip of the bar is always digging in the dirt, which is common in limb removal operations. Because it is difficult to predict when the chain will become dull, experienced operators will start each day with a sharp chain on the saw and a spare sharp chain in the tool box.

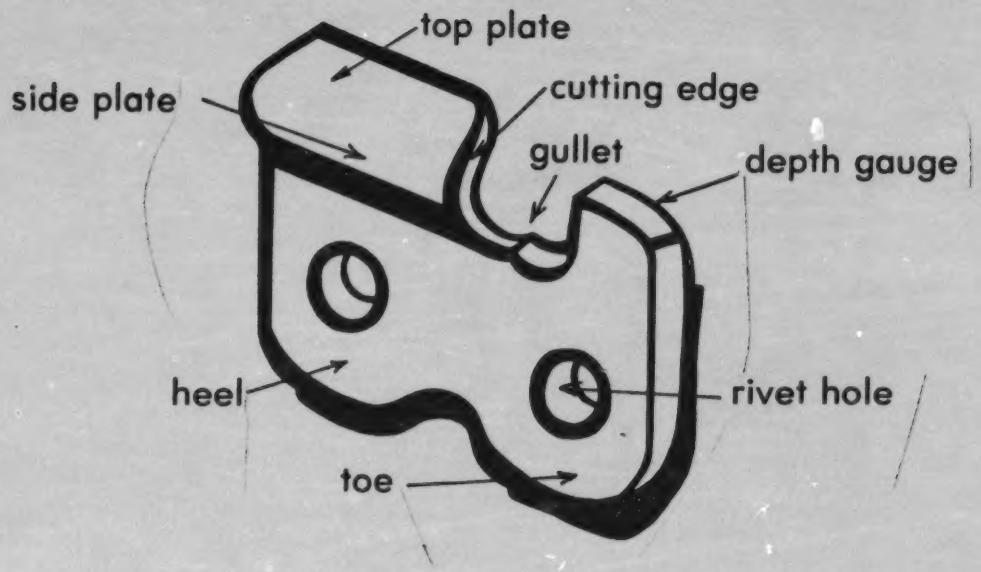
Sharpening the Chain

There are two types of cutting links which are used in chain saw chains. Each type uses a different angle for sharpening, so be sure to identify which type you have. Both types are shown below.

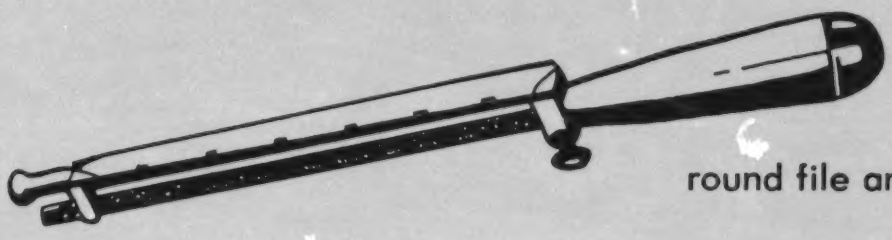


Chipper Chisel

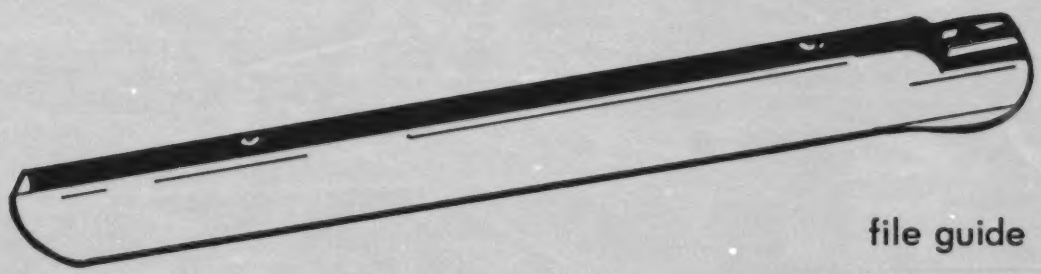
It is also important to know the parts of a cutter as you work the chain. When sharpening, the cutting edge is important; but careful attention must also be paid to the depth gauge. If the depth gauge extends above the top plate, the depth gauge will drag and cause extra heat to build up when cutting. The parts of a cutter are shown in the following illustration.



Sharpening a chain saw, like many other jobs, is much easier if the proper tools are used. For sharpening, two tools are needed - a full round file with a holder and a file guide. The correct size of file to use will depend on the pitch of the chain used. Consult your chain saw dealer for the correct size. The holder for the file has the file sharpening angle marked on the back to help keep the precise angle when sharpening the cutting edge. Both tools are shown below.



round file and holder

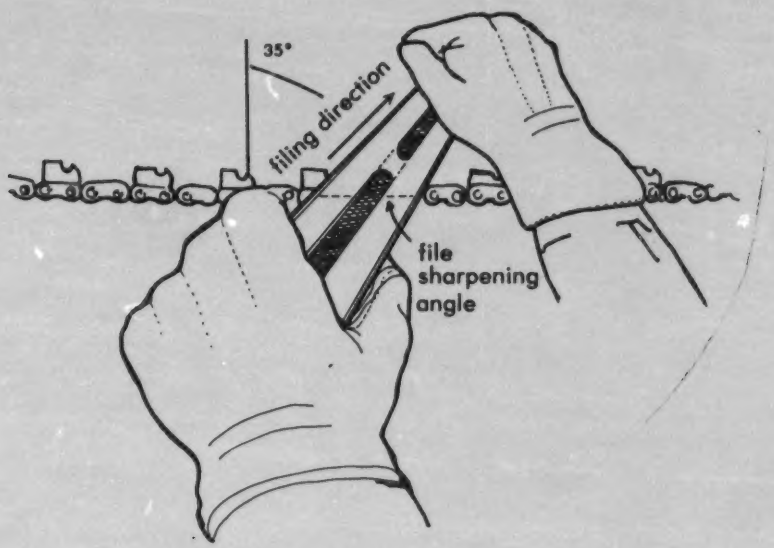


file guide

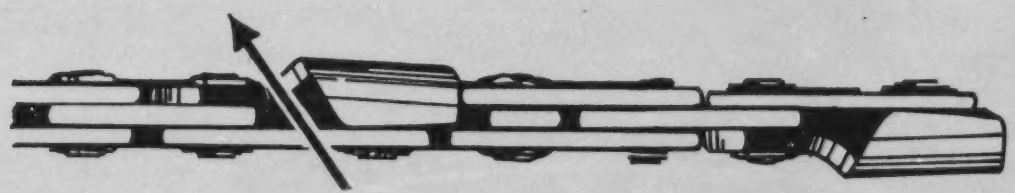
Before sharpening the chain, put on safety glasses and leather gloves to protect eyes and hands. The spark plug wire should be disconnected and grounded to the engine block. This will prevent accidental starting of the chain saw while you are working on it.

To file cutters, follow these steps:

1. Place the file in one of the cutters whose side plate is on the side away from you. Keep the file at a 35-degree angle to the bar for chipper type chains. Keep the file sharpening angle marked on the file holder parallel to the bar, as illustrated.



2. Keeping the file level, file from the inside out as illustrated. Maintain firm pressure on the file. Give the cutter two strokes. Do not file on the back stroke.



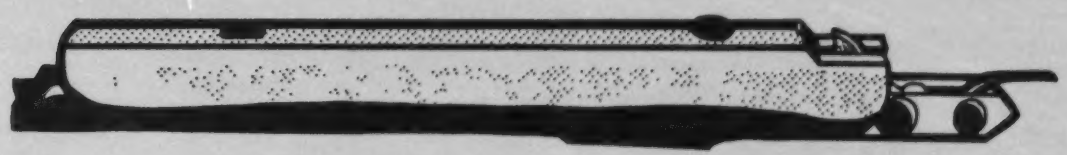
3. Move to the next cutter on the same side and repeat the procedure. Using a gloved hand, rotate the chain as needed to sharpen all the teeth on that side.

4. Turn the saw around and sharpen all of the cutters on the other side.

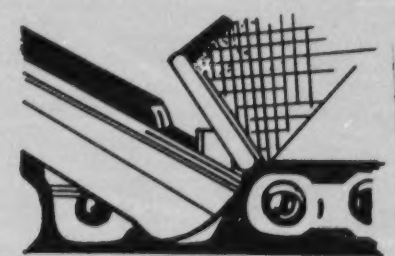
5. Reattach the spark plug wire to the spark plug.

Gauging the Depth on the Chain

The depth gauges should be checked every third or fourth chain sharpening. For this operation, too, the spark plug wire should be disconnected and grounded to the engine block. Check the depth gauges by using a file guide, as shown in the following illustration.



If the top of the depth gauge extends above the file guide, such as the one illustrated above, file it off even with the file guide using a flat file. After filing the top of the depth gauge, round off the front corner of the depth gauge to keep it from dragging. Tilt the file guide up and use it to protect the cutting edge while doing this, as shown below.



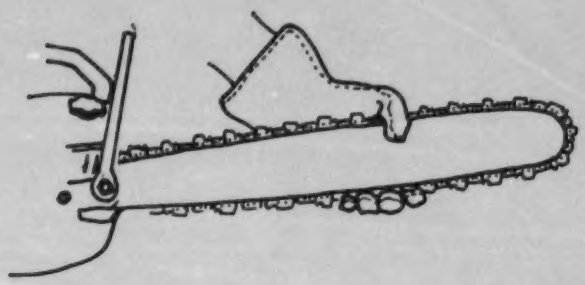
Repeat this process until all of the depth gauges have been checked and worked. Reattach the spark plug wire.

Adjusting Chain Tension

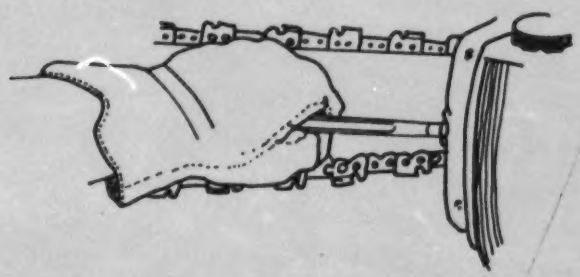
Keeping the chain at the proper tension is also important for efficient cutting and reduced wear and tear on the chain saw. When adjusting the chain tension, always wear a leather glove to protect the hand which handles the chain. The spark plug wire should also be removed from the spark plug and grounded to the engine block.

To adjust the chain to the correct tension:

1. Loosen the bar nuts, as illustrated.



2. If the saw has a chain tension screw, adjust it in or out until the chain just touches the bottom rails of the bar. At that point, pull up on the chain at the top of the bar to make sure that the chain will not come out of the groove. (See illustration.)



If the saw has no chain tension screw, chain tension is adjusted by sliding the bar in or out, then tightening the bar nuts.

3. Oil the chain, then pull the chain around the bar by hand. Make sure that the chain is still in proper adjustment.

4. Hold the tip of the bar up as high as it will go and tighten the bar nuts.

5. Pull the chain around the bar again and make sure it moves freely.

6. Reconnect the spark plug wire to the spark plug.

Summary

When sharpening a chain saw, it is important to remember that the chain will get dull at varying rates of speed, depending on the type of wood being cut, how often the saw is used, and the working conditions. When working with the chain saw, sharpening it or adjusting the tension, always wear leather gloves as well as disconnecting the spark plug wire and grounding it to the engine block. File cutters at a 35-degree angle, giving each cutter two strokes. Check the depth gauges every third or fourth sharpening and file down as needed. Adjust the chain tension as needed.

Credits

1. Chain Saw Maintenance and Safety, Donald Farrand.

2. Chain Saw Repair, Mark Taylor and Wayne Helbing.

UNIT - TOOL SHARPENING AND RECONDITIONING

SHOP DEMONSTRATION #3: Sharpening a Chain Saw

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise in sharpening a chain saw.

Tools Needed:

1. Full round chain file and holder of the correct size for the chain being sharpened
2. File guide
3. Flat file
4. Combination wrench set
5. Standard or phillips screwdrivers
6. Safety glasses
7. Leather gloves

Materials Needed:

1. Chain saw, with dull chipper type chain
2. Recommended chain oil

Procedure:

Step 1: Demonstrate how to disconnect the spark plug wire and ground it to the engine block.

Step 2: Demonstrate how to hand sharpen a chipper type chain.

a) Place the file in one of the cutters holding the file at 35 degrees to the bar (for chipper type chains) and keeping the file sharpening angle marks on the file holder parallel to the bar.
b) File from the inside out, keeping the file level.
c) Give each cutter two strokes.
d) Move to the next cutter on the same side and repeat the process.
e) Using a gloved hand, rotate the chain as needed until all of the cutters on that side are sharpened.
f) Turn the saw around and sharpen all of the cutters on the other side.

Step 3: Demonstrate gauging the depth on the chain.

a) Using the file guide, check the depth gauges.
b) File off that part of any depth gauge which extends above the file guide.
c) Round off the corner of any depth gauge which was filed down. Use a flat file for this operation. Tilt the file guide upward to protect the sharpened cutter while performing this operation.
d) Repeat this process until all depth gauges have been checked and worked.

Step 4: Demonstrate how to adjust the chain tension.

a) Loosen the bar nuts.
b) Adjust the chain tension screw in or out until the chain just touches the bottom rails of the bar.
c) Pull up on the top of the chain to make sure it will not come up out of the groove in the bar.
d) Oil the chain, then pull the chain around the bar by hand. Recheck to see that the chain is still in adjustment.
e) Hold the tip of the bar up as high as it will go and tighten the bar nuts.
f) Pull the chain around the bar again and make sure it moves freely.
g) Reconnect the spark plug wire to the spark plug.

UNIT - TOOL SHARPENING AND RECONDITIONING

SHOP EXERCISE #3: Sharpening a Chain Saw

Objective: At the end of this exercise, the student should be able to sharpen a chain saw.

Tools Needed:

1. Full round chain file and holder of the correct size for the chain being sharpened
2. File guide
3. Flat file
4. Combination wrench set
5. Standard or phillips screwdrivers
6. Safety glasses
7. Leather gloves

Materials Needed:

1. Chain saw, with dull chipper type chain
2. Recommended chain oil

Procedure:

Step 1: Disconnect the spark plug wire and ground it to the engine block.

Step 2: Hand sharpen a chipper type chain.

a) Place the file in one of the cutters holding the file at 35 degrees to the bar (for chipper type chains) and keeping the file sharpening angle marks on the file holder parallel to the bar. (Refer to Figure 1.)
b) File from the inside out, keeping the file level. (Refer to Figure 2.)
c) Give each cutter two strokes.
d) Move to the next cutter on the same side and repeat the process.
e) Using a gloved hand, rotate the chain as needed until all of the cutters on that side are sharpened.
f) Turn the saw around and sharpen all of the cutters on the other side.

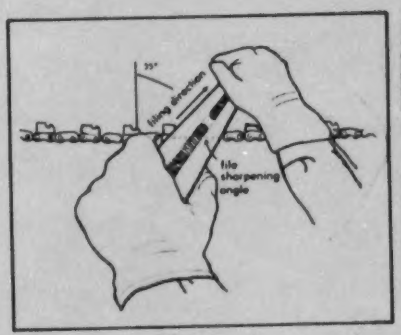


Figure 1

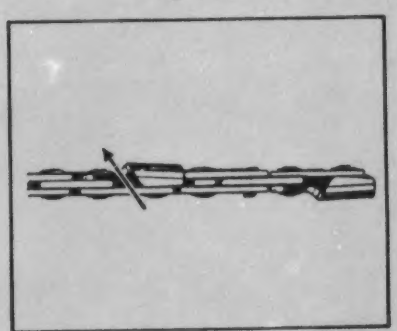


Figure 2

Step 3: Gauge the depth on the chain.

a) Using the file guide to check the depth gauges.
b) File off that part of any depth gauge which extends above the file guide. (Refer to Figure 3.)
c) Round off the corner of any depth gauge which was filed down. Use a flat file for this operation. Tilt the file guide upward to protect the sharpened cutter while performing this operation. (Refer to Figure 4.)
d) Repeat this process until all depth gauges have been checked and worked.

Step 4: Adjust the chain tension.

a) Loosen the bar nuts. (Refer to Figure 5.)
b) Adjust the chain tension screw in or out until the chain just touches the bottom rails of the bar. (Refer to Figure 6.)
c) Pull up on the top of the chain to make sure it will not come up out of the groove in the bar.
d) Oil the chain, then pull the chain around the bar by hand. Recheck to see that the chain is still in adjustment.
e) Hold the tip of the bar up as high as it will go and tighten the bar nuts.
f) Pull the chain around the bar again and make sure it moves freely.
g) Reconnect the spark plug wire to the spark plug.

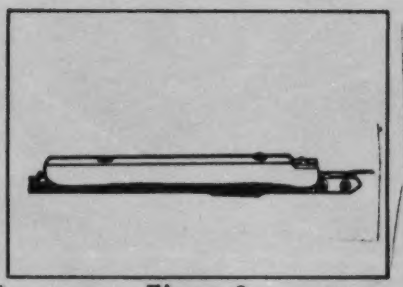


Figure 3

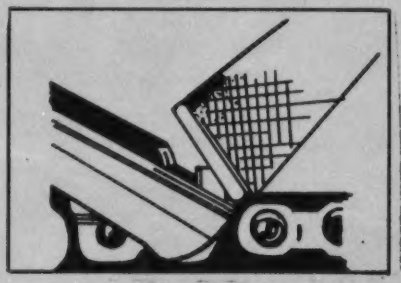


Figure 4

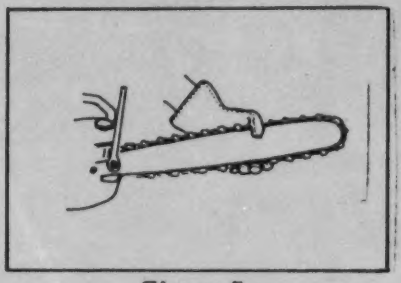


Figure 5

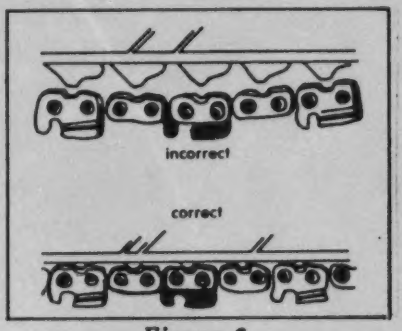


Figure 6

UNIT - COLD METAL WORK

Lesson 1: How do I work with cold metal?

Objective: At the end of this lesson, the student will be able to lay out, cut, shape, and fasten cold metal.

Study Questions:

1. **How can I lay out and mark work to be done in cold metal?**
2. **How do I cut cold metal?**
3. **How can cold metal be shaped?**
4. **How do I fasten cold metal?**
5. **How should the metal be deburred?**

References:

1. Modern Agricultural Mechanics, Wakeman, Chapters 6 and 9.
2. Shopwork on the Farm, Jones, Chapters 11 and 12.
3. Transparency Masters
   a. TM-1: Selecting a Hacksaw Blade
   b. TM-2: Cutting Metal with a Cold Chisel
   c. TM-3: Types of Cold Chisels
   d. TM-4: Cutting Sheet Metal with Tin Snips
   e. TM-5: Types of Files
   f. TM-6: Filing Metal
   g. TM-7: Cold Forming Metal
   h. TM-8: Setting Cold Rivets
   i. TM-9: Pop Riveting
   j. TM-10: Types of Taps
   k. TM-11: Using a Die
4. Shop Demonstration
   a. #1: Making a Small Shelf Bracket
5. Shop Exercise
   a. #1: Making a Small Shelf Bracket

UNIT - COLD METAL WORK

Lesson 1: How do I work with cold metal?

TEACHING PROCEDURES

A. Review: At the start of this unit, review with the class the types of fasteners suitable for fastening metal to metal or metal to wood. This information is contained in the Wookworking Unit, Lesson 5 of the Agricultural Mechanics Unit for Animal Science Core Curriculum.

B. Motivation: Ask the students when it would be advantageous to work metal cold. (Examples would include speed, economy, and wherever there is the danger of fire.)

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students how to lay out and mark work to be done in cold metal.

How can I lay out and mark work to be done in cold metal?

1) Layout can be done with chalk or soapstone for rough work.
2) For fine work, paint the area with layout fluid (which is usually blue). Layout fluid is an excellent background and shows marks well.
3) After layout fluid has been applied, the pattern can be laid out by using various measuring devices and a scriber or scratch awl.
4) A center punch can be used to locate the center of holes to be drilled.

2. Ask the students how metal can be cut cold. List the methods on the chalkboard. Show TM-1, TM-2, TM-3, and TM-4 to the students. Ask the students how to perform each skill.

How do I cut cold metal?

1) Methods of cutting metal cold
   a) Hacksawing
   b) Using a cold chisel
   c) Using bolt cutters
   d) Using tin snips
   e) Using a metal shear
2) Hacksawing
   a) Blades commonly come with 14, 18, 24, or 32 teeth per inch.
   b) General rule is to select a blade which will have at least three teeth cutting at one time. (Refer to TM-1.)
   c) When replacing blades, make sure that the teeth are pointing down and forward and that the blade is tight.
   d) Use long, slow, even cutting strokes at the rate of 40 to 50 forward strokes per minute.
   e) Let the saw do the work. Use just enough pressure to make the teeth cut.

f) If the blade breaks, always start the cut again in a new place.

3) Using a cold chisel
   a) Hold the chisel near the end away from the point.
   b) Strike firm blows against the chisel with a machinist's hammer.
   c) Hold the chisel at a 60-degree angle to the work for shearing work 1/8-inch thick or less. (Refer to TM-2.)
   d) For metal heavier than 1/8-inch thick, place the metal flat on the chipping block of the anvil. Begin to cut at both edges, progressing toward the center. After the stock has been nicked across its entire width, turn the bar over and repeat the procedure. The bar can then be bent back and forth until it breaks.
   e) Round stock can be cut in a similar manner as thicker metal (described above).
   f) There are special types of chisels for special uses. (Refer to TM-3.)
      (1) Flat - general uses
      (2) Cape - cutting rectangular grooves
      (3) Round nose - cutting round grooves
      (4) Diamond point - cutting square grooves
      (5) Slitting - cutting thicker sheet metal

4) Using bolt cutters
   a) Place the metal to be cut as far to the rear of the jaws as possible.
   b) Pull the handles together without allowing the cutters to twist.

5) Using tin snips
   a) To make straight cuts, keep the cutting edge of the upper blade directly on the line to be cut. (Refer to TM-4.)
   b) When cutting large sheets, insert the metal as far back into the snips as possible, cut out almost to the tips, then take another cut.
   c) For shorter cuts, work with the tips of the snips for greater control.

6) Using a metal shear
   a) Align the cutting line with the stationary jaw.
   b) Do not exceed the capacity of the shear.

3. Show TM-5 to the students. Ask the students to identify each type of file. Show TM-6 to the students. Ask the students how to shape metal by filing. Show TM-7 to the students. Ask the students how to bend cold metal.

How can cold metal be shaped?

1) Types of files are classified by length, coarseness, shape, and type of teeth. (Refer to TM-5.)
   a) Coarseness - bastard cut, second cut, smooth cut
   b) Shape - flat, round, half-round, three-cornered
   c) Type of teeth - single cut, double cut, rasp cut, curved tooth

2) Shaping metal by filing (Refer to TM-6.)
   a) Never use a file without a handle.
   b) To keep files sharp, make sure that they are stored properly.
   c) Hold the file with both hands.
   d) Use long even strokes with the file.
   e) Only apply pressure on the forward stroke of the file.

f) Keep the file clean by using a file card when necessary.
g) The material being filed should be held securely in a vise, with the area to be filed located just above the jaws to reduce vibration.

3) Bending cold metal
   a) One method is to place the metal in the vise, then push with one hand while hammering just above the vise jaws until the desired angle is obtained.
   b) Another method would be to place a long piece of pipe over the piece to be bent, then bend as if you were bending hot metal.
   c) Eyes can be formed cold by bending the metal around a piece of round stock.
   d) Twisting the metal can be accomplished by placing the metal in the vise just below the twist, then twist by placing an adjustable open-end wrench on the upper part of the piece, twisting until the desired effect is reached.
   e) Metal benders can also be used to make various bends in cold metal. Follow the directions provided with the bender.

4. Show TM-8 to the students. Ask the students how to set cold rivets. Show TM-9 to the students. Ask the students how to pop rivet sheet metal. Show TM-10 to the students. Ask the students how to use these types of taps. Show TM-11 to the students. Ask the students how to use a die.

How do I fasten cold metal?

1) Setting cold rivets (Refer to TM-8.)
   a) Drill the hole for the rivet with the same size twist drill as the size of the rivet.
   b) Select a rivet that will extend 1/16 to 1/8-inch above the surface of the joined pieces.
   c) Draw the pieces of metal together. (A rivet set has a special hole which fits over the rivet for this purpose.)
   d) Tighten the rivet by directing the first blows straight down on the rivet, causing the shank to expand.
   e) The final blows should be made with the peen of the hammer or with a rivet set. Do not flatten the head of the rivet, this weakens the rivet.
2) Pop riveting (Refer to TM-9.)
   a) Pop rivets can be used in blind locations to fasten metal.
   b) Pop rivets are sized by diameter and grip length of the head.
   c) Select rivets which are compatible with the metal being fastened. Do not use aluminum rivets on steel.
   d) Drill the hole for the rivet the same diameter a the pop rivet.
   e) To install pop rivets, place the pin of the rivet into the nose of the pop rivet gun.
   f) Press the rivet firmly into the hole, making sure that the pieces of metal are pressed firmly together.
   g) Draw the rivet up by squeezing the handles of the gun together until the pin breaks. This may require several strokes.
3) Using taps
   a) Types of taps (Refer to TM-10.)
      (1) Tapered - used for cutting threads in an open hole.

(2) Plug - used where a self-tightening thread is needed, such as for a set screw. Must use the tapered tap first, then the plug tap.

(3) Bottoming - used in a blind hole where a stud bottoms out inside the hole. Must use a tapered tap, then the plug tap, before using the bottoming tap.

b) There are five main thread types.
   (1) National Coarse (NC)
   (2) National Fine (NF)
   (3) ISO coarse (coarse metric threads)
   (4) ISO fine (fine metric threads)
   (5) National Pipe Threads (NPT)

c) Coarse threads make for quicker assembly and resists cross-threading.

d) Fine threads are used in high stress and high load situations because they are less likely to loosen under those conditions.

e) NC, NF, ISO coarse, and ISO fine threads are cut at a constant depth throughout.

f) NPT threads are tapered to make for a tight fit when pipe is screwed into a pipe fitting.

g) To determine the correct pilot hole size to drill for tapping, use the follwoing formula:

$$\text{Pilot hole size} = \text{Tap size} - \frac{1}{\text{Number of threads per inch}}$$

Example: If a 3/8-16 NC tap is used, a 5/16" pilot hole should be drilled.

$$3/8\text{" tap} - \frac{1}{16 \text{ threads per inch}} = 5/16\text{" pilot hole size}$$

(6/16 - 1/16 = 5/16)

h) After the pilot hole has been drilled, insert the tap squarely into the hole. Putting even pressure on the tap wrench, turn slowly clockwise.

i) Use an appropriate lubricant to remove chips and reduce friction. For cutting threads in steel, use cutting oil. Water-soluble oil will not do an adequate job when cutting threads.

j) As the turning continues, only a slight downward pressure is needed.

k) When the tap reaches the bottom of the hole or it turns free after finishing, remove the tap by turning the wrench counterclockwise. Remove any extra cutting fluid.

4) Using a die
   a) Dies are used to cut threads on a rod or bolt.
   b) Dies are available in the same thread systems as taps.
   c) To begin the threading operation, start with a piece of stock that is square on the end, the file a 45-degree chamfer on the end of the rod.
   d) Hold the die stock squarely over the bolt and, while applying moderate downward pressure, turn the die 1/2-turn in a clockwise direction.
   e) Apply cutting fluid, and turn another 1/2-turn.

f) Continue turning clockwise, applying more cutting fluid every two to three turns.
g) When the desired length has been threaded, reverse directions and turn the die stock until it is removed.

5. Ask the students how to deburr the metal.

How should the metal be deburred?

1) Deburring is done to remove a wire edge often left when metal is cut or drilled.
2) This should be done for safety (the burr is sharp and makes handling dangerous) as well as for improving the fit-up when fastening pieces of metal together.
3) Deburring on cuts in metal can be done by cutting a small chamfer on the edges with a grinder or a bastard file.
4) Deburring holes can be done by cutting a small chamfer around the edge of the hole with a drill bit two times the size of the hole.

F. Other Activities

Shop Demonstration
#1: Making a Small Shelf Bracket

Shop Exercise
#1: Making a Small Shelf Bracket

The instructor may wish to demonstrate additional skills and require additional exercises to practice other cold metal skills discussed in this lesson, as time allows.

Also appropriate would be additional student exercises in determining pilot hole sizes for tapping. These could be assigned as homework exercises.

G. Summary

When working with cold metal, a student should:

1. Use layout fluid or chalk to lay out the work to be done.
2. Use hacksaws, cold chisels, bolt cutters, tin snips, and metal shears properly to cut metal.
3. Use the proper files and other tools to bend and shape metal.
4. Use cold rivets, pop rivets, and bolts to fasten metal together.
5. Deburr cuts and holes in metal for safety and better fit-up.

H. Answers to Evaluation

1.	T	6.	T	11.	T
2.	F	7.	F	12.	F
3.	T	8.	F	13.	F
4.	T	9.	T	14.	T
5.	T	10.	T	15.	F

UNIT - COLD METAL WORK

Lesson 1: How do I work with cold metal?

EVALUATION

The following statements are either true or false. Circle T if the statement is true; circle an F if the statement is false.

T F 1. Deburring holes drilled in metal can be done by cutting a chamfer with a drill bit two times the diameter of the hole.

T F 2. To keep from breaking hacksaw blades, select a blade which will have at least one tooth in contact with the metal at all times.

T F 3. Hold a cold chisel at a 60-degree angle to the work when shearing pieces 1/8-inch thick.

T F 4. To cut a straight line with tin snips, keep the cutting edge of the upper blade directly on the line to be cut.

T F 5. A centered eye bend can be made in cold metal by forming the bend around a piece of round stock in a vise.

T F 6. Never use a file without a handle.

T F 7. The head of a cold rivet should be flattened for greater strength.

T F 8. Aluminum pop rivets are suitable for fastening steel together.

T F 9. When cutting threads for a set screw, a tapered tap should be used first, then a plug tap.

T F 10. Pipe threads are tapered to make pipe self-tightening as it is screwed into a fitting.

T F 11. For a 3/4-16 NF tap, an 11/16-inch pilot hole should be drilled.

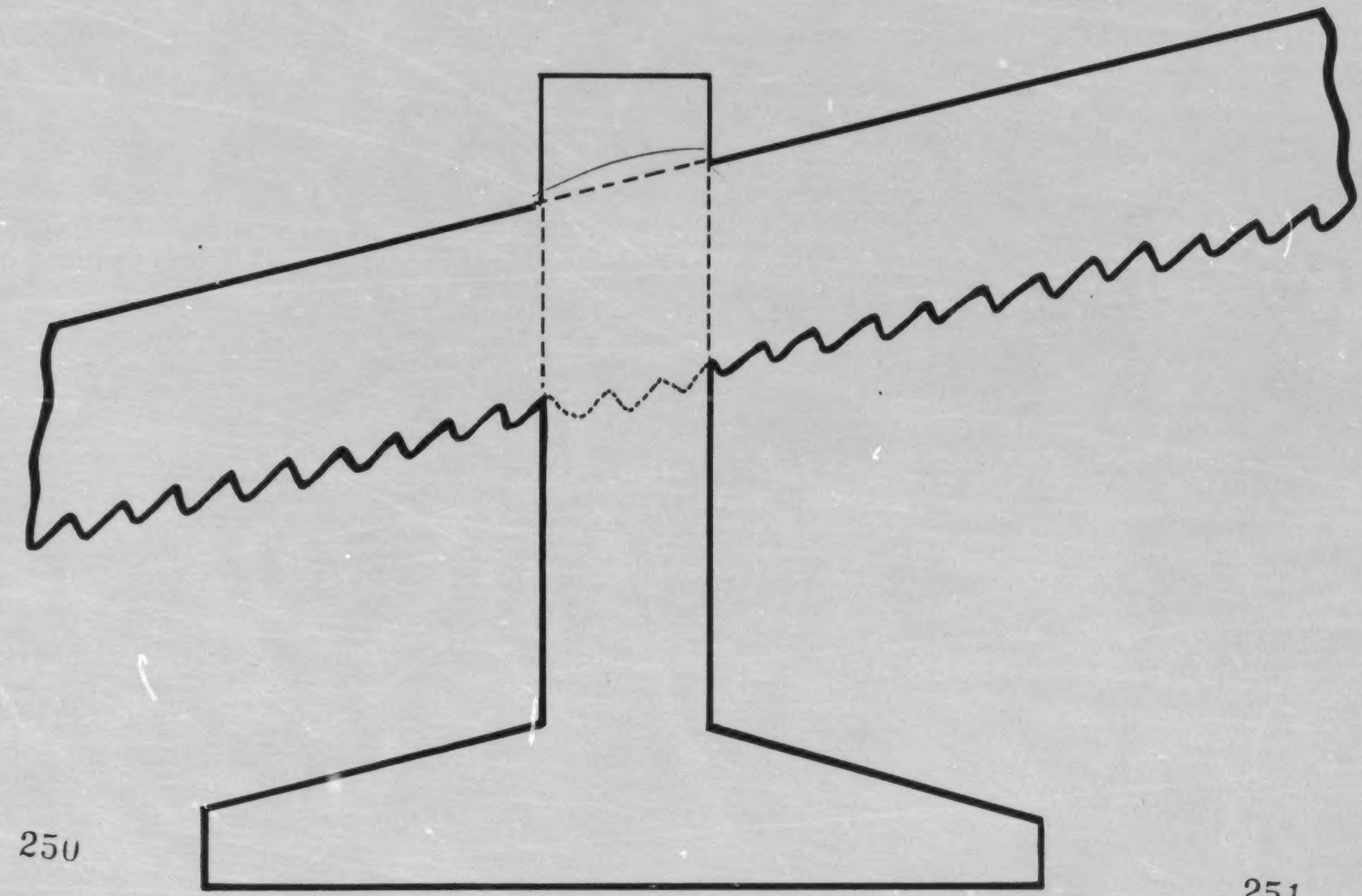
T F 12. Water-soluble oil is a suitable lubricant for cutting threads.

T F 13. Hacksawing should be done at a rate of 60 to 70 strokes per minute.

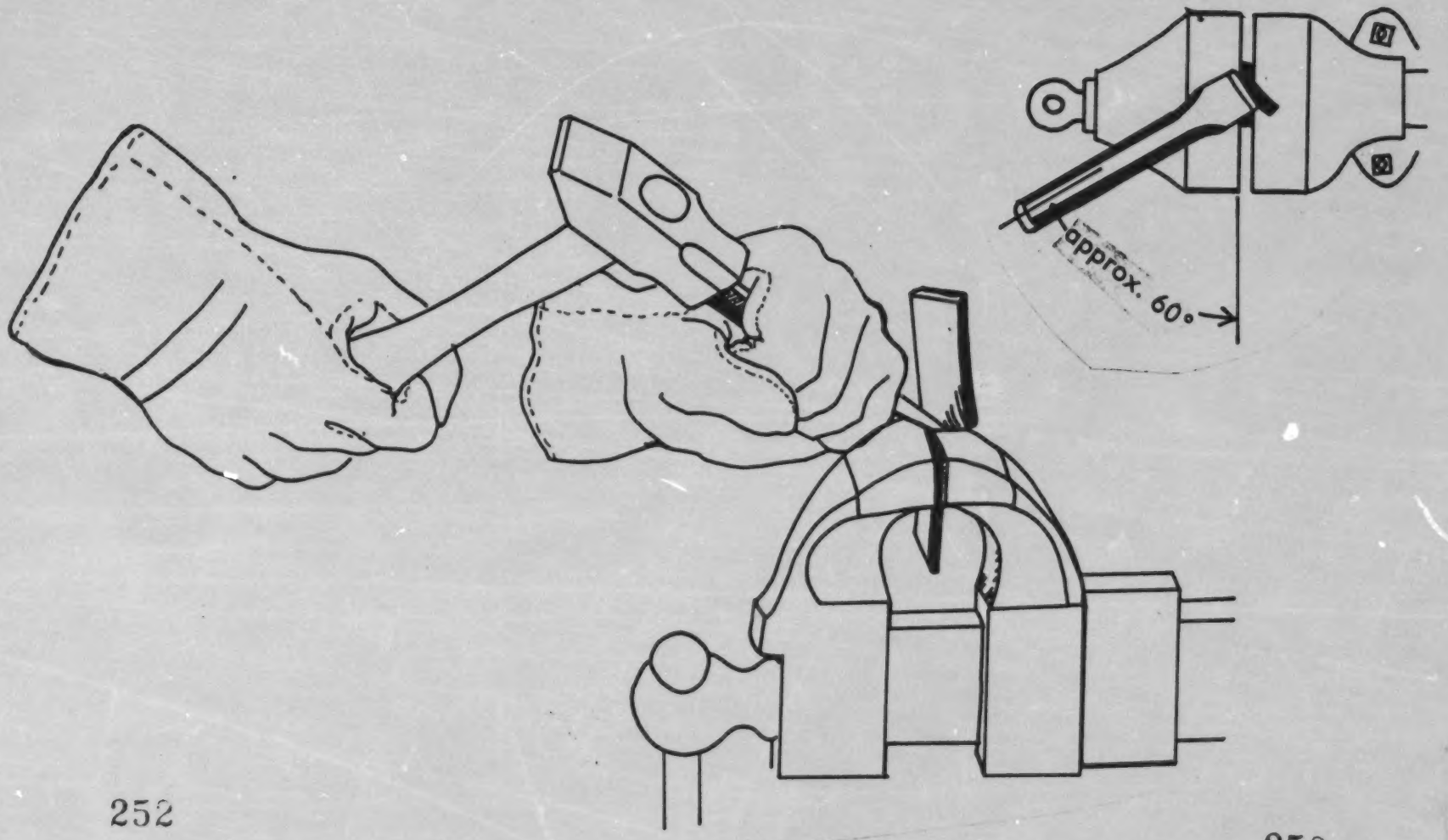
T F 14. A scriber or scratch awl is used with layout fluid to lay out fine work in cold metal.

T F 15. When using bolt cutters, the bolt to be cut should be placed as close to the tips of the blades as possible for greater leverage.

Selecting a Hacksaw Blade



Cutting Metal With a Cold Chisel



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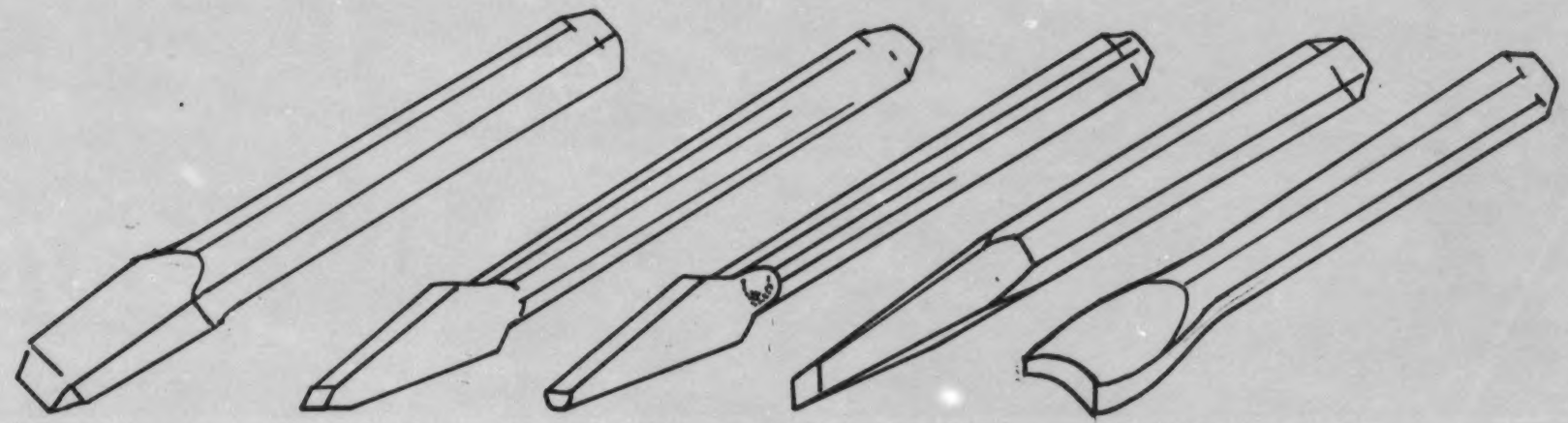
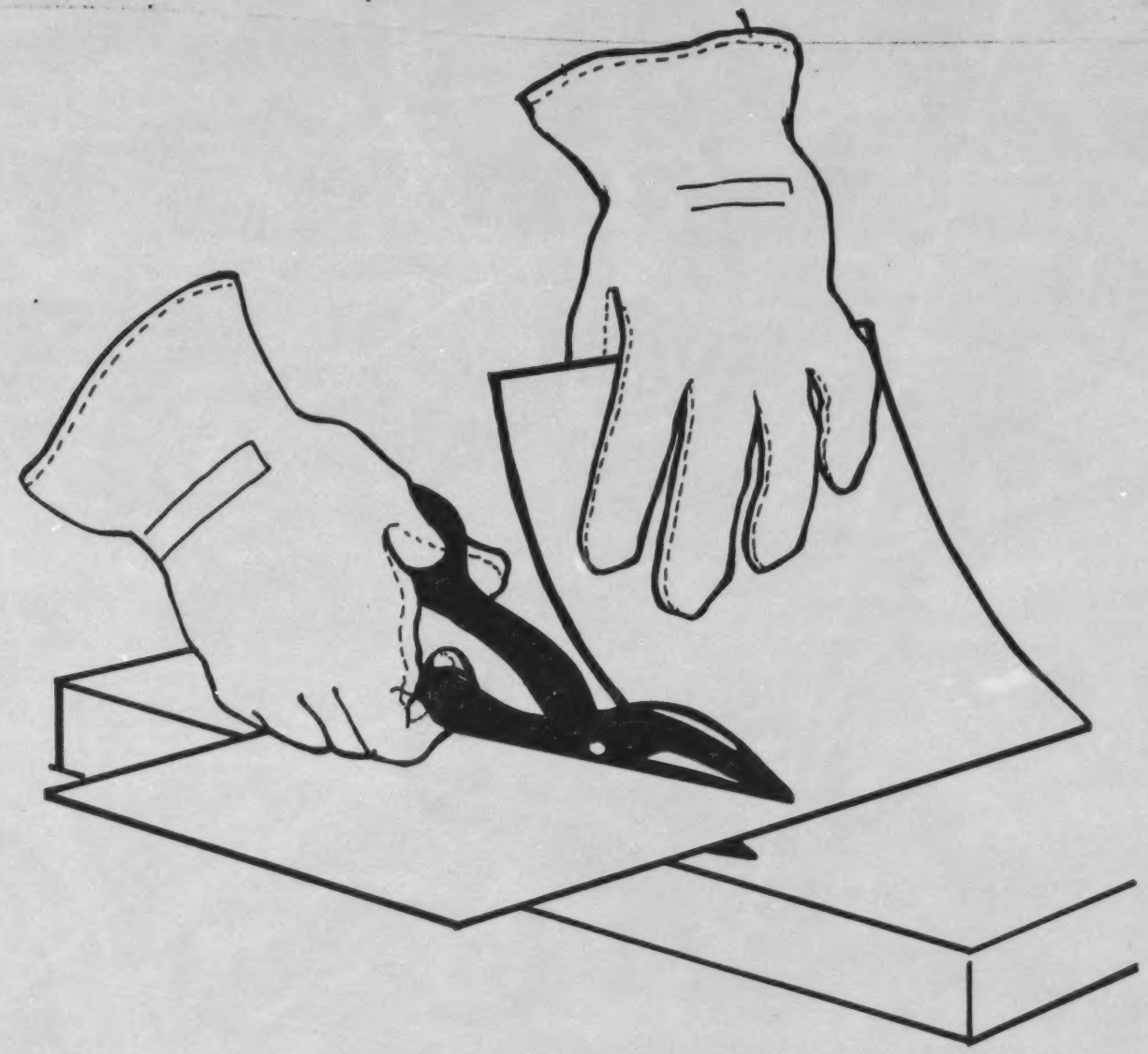
TM-2

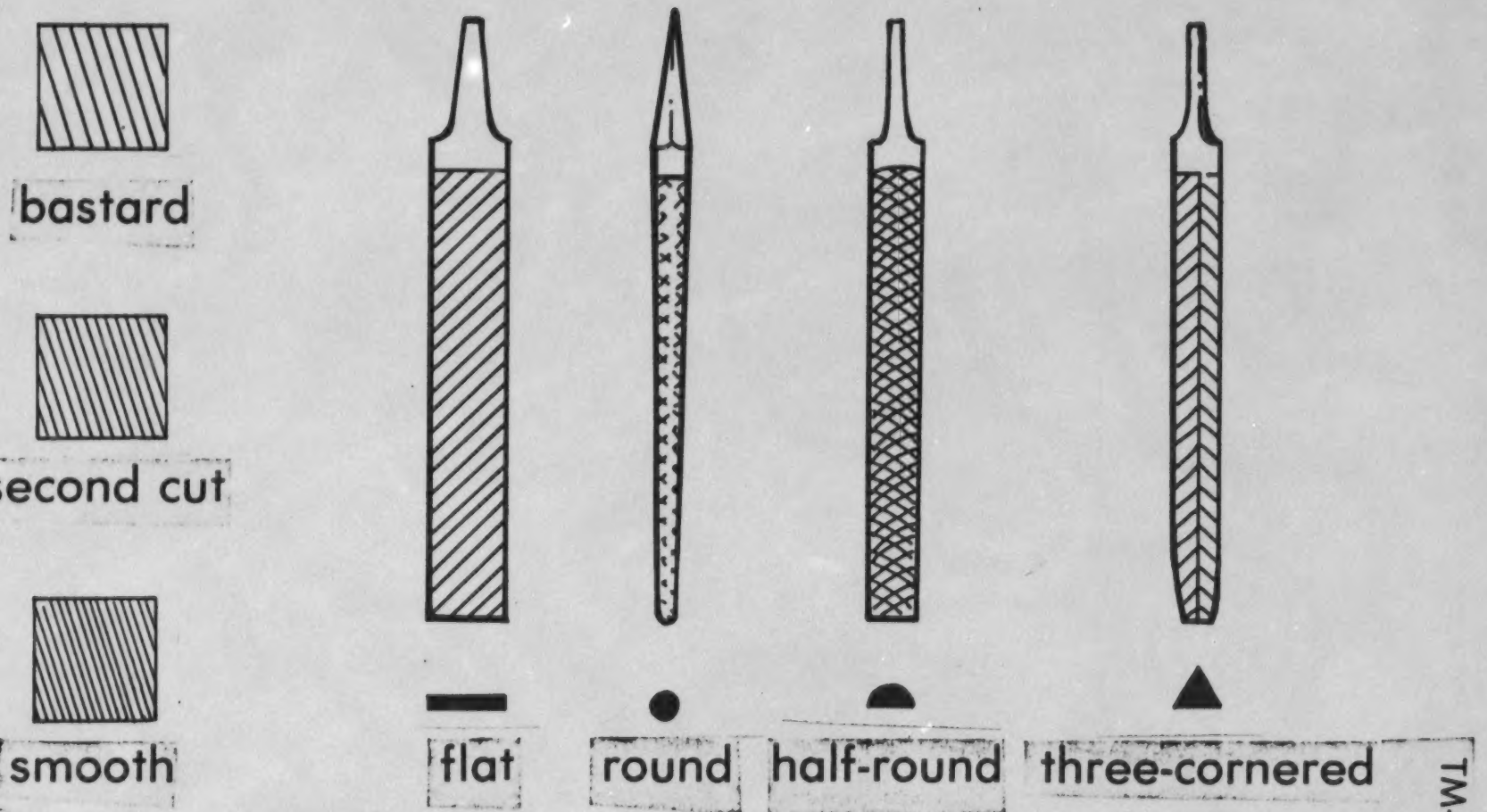
Types of Cold Chisels



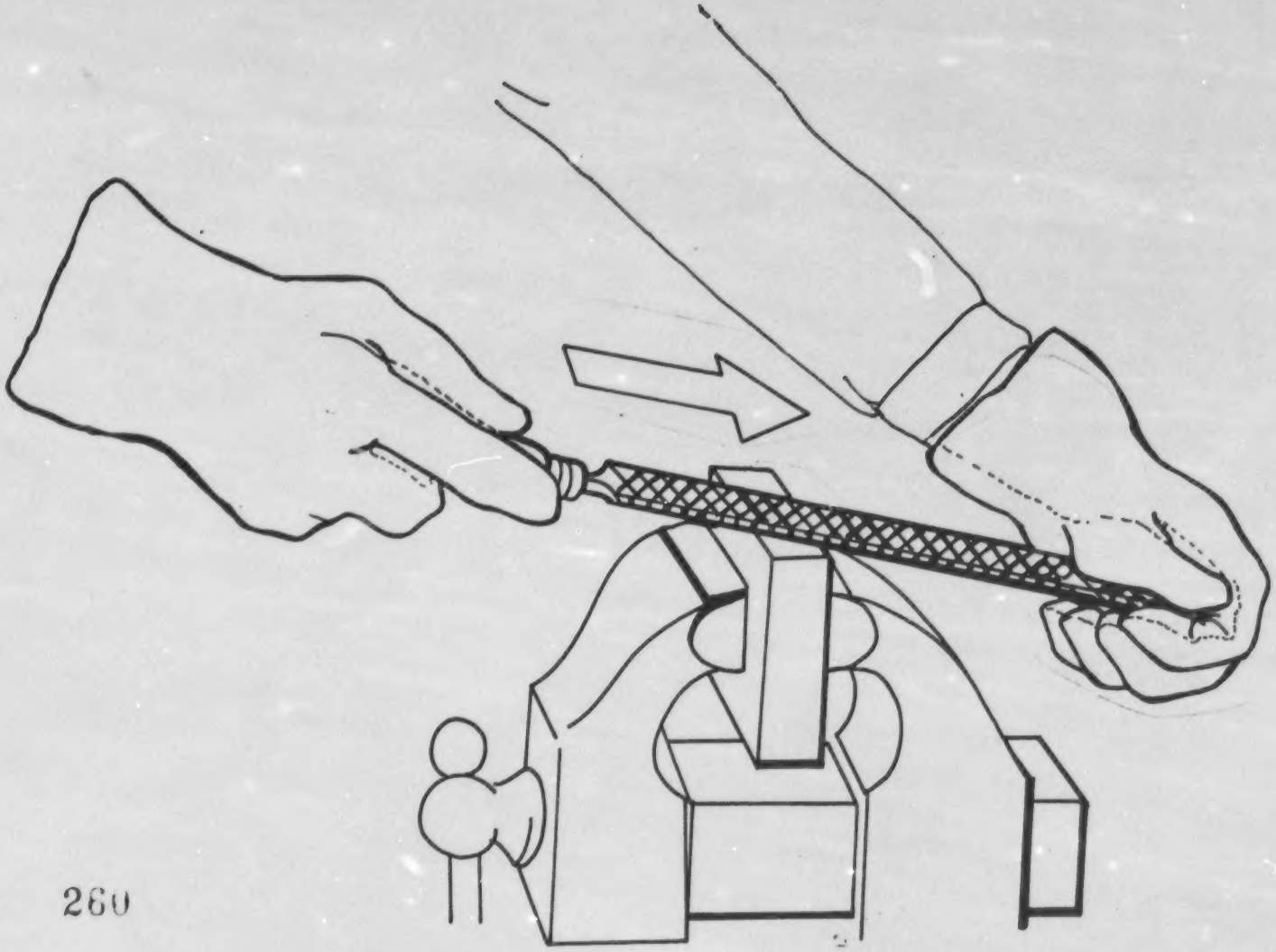
Cutting Sheet Metal with Tin Snips



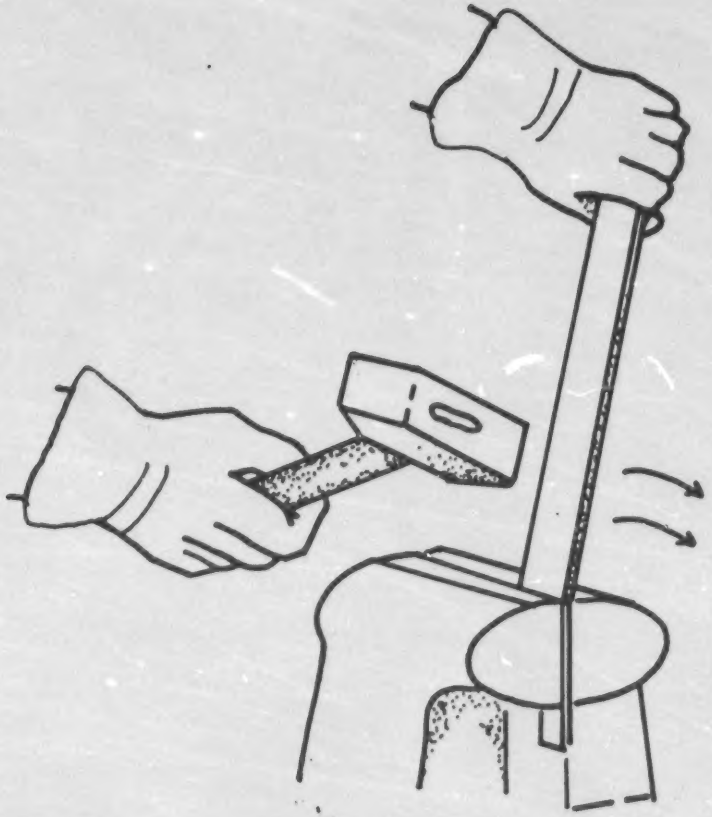
Types of Files



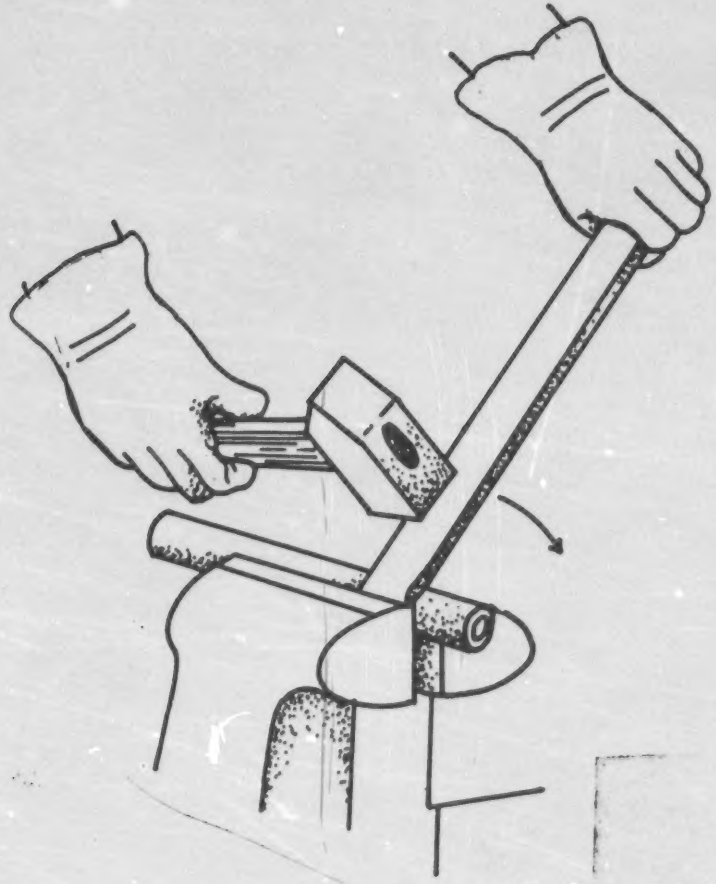
Filing Metal



Cold Forming Metal



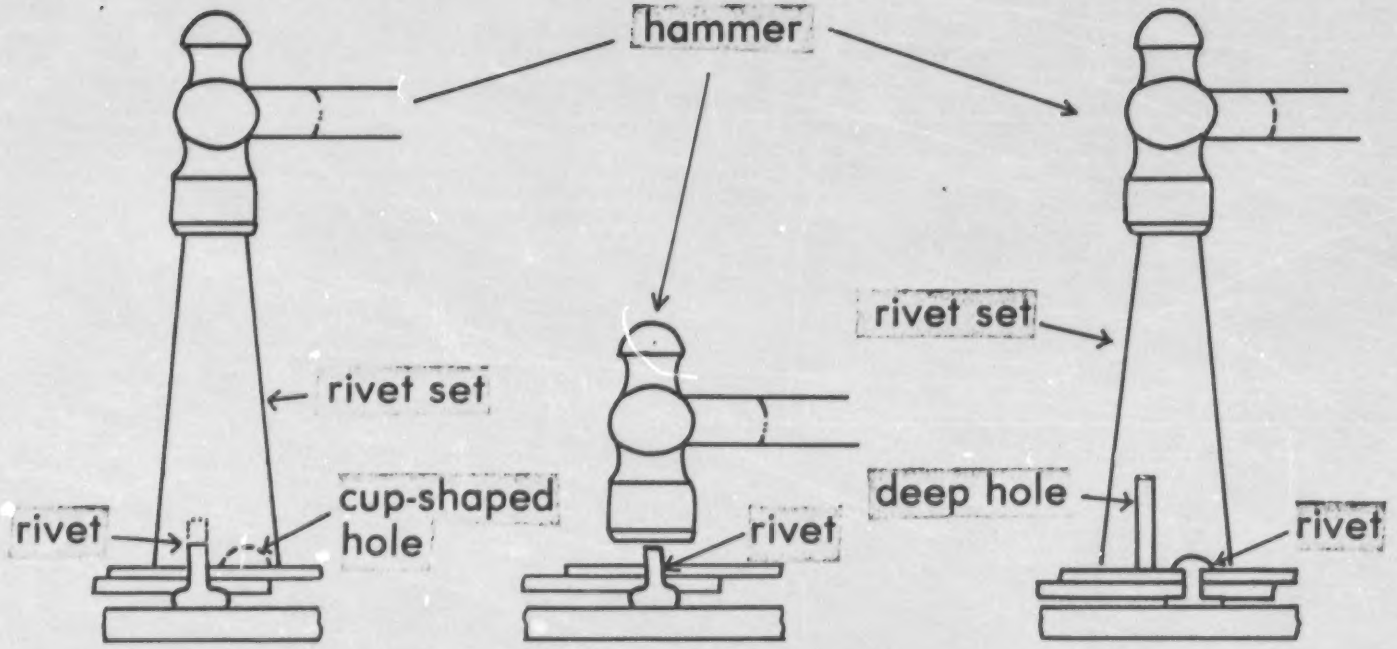
262



263

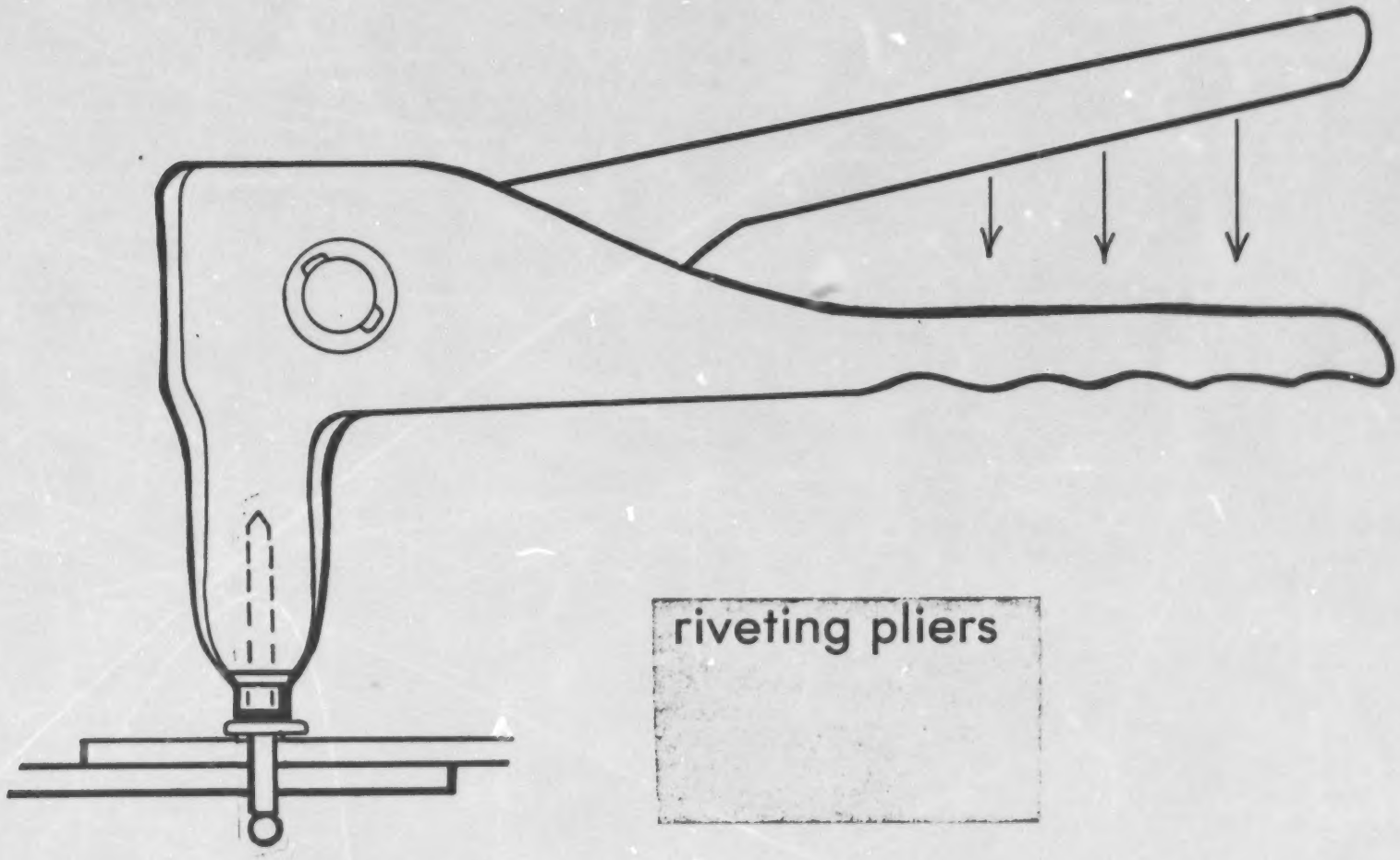
TM-7

Setting Cold Rivets



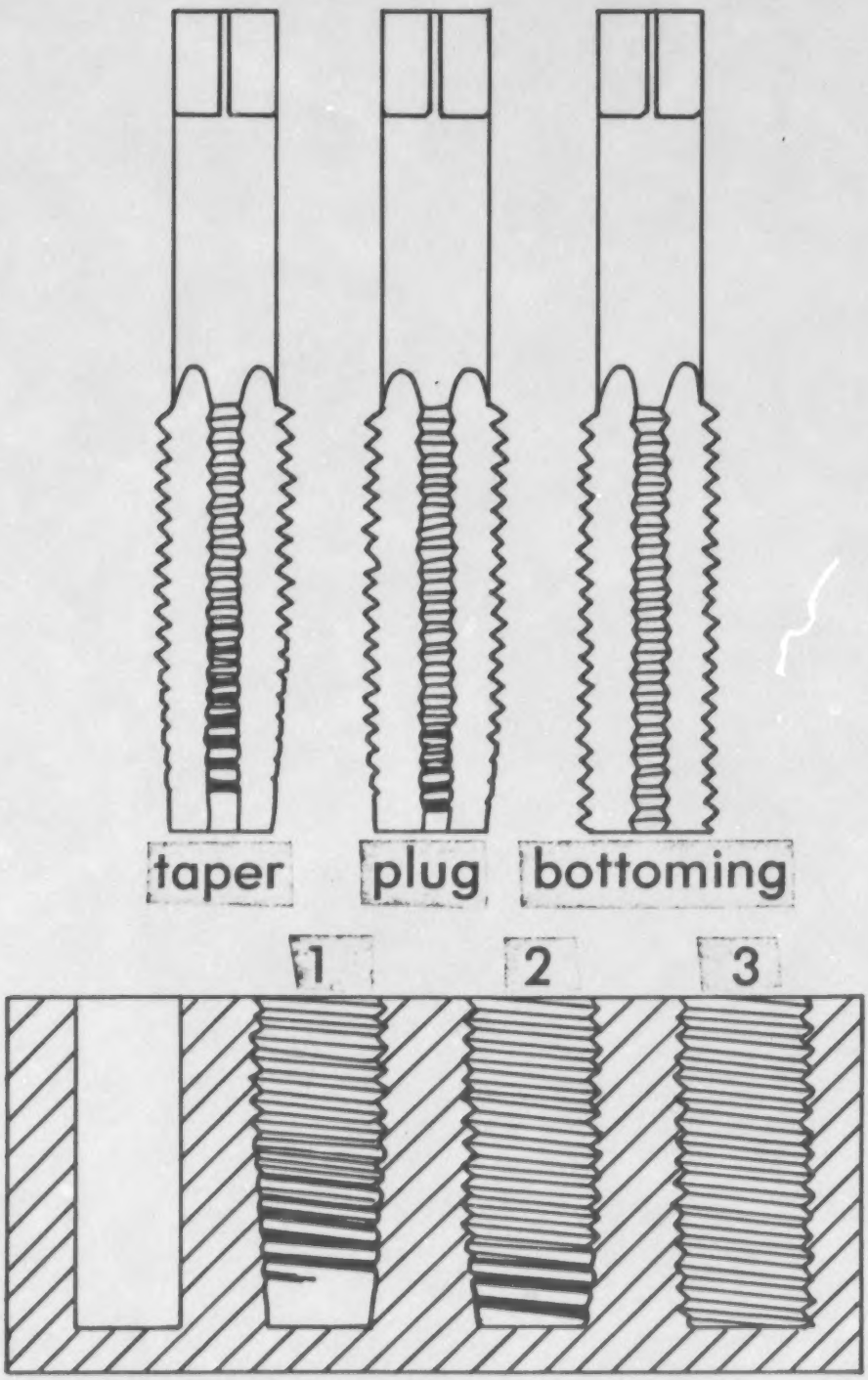
1. Metal drawn together
2. Rivet tightened
3. Rivet head formed

Pop Riveting

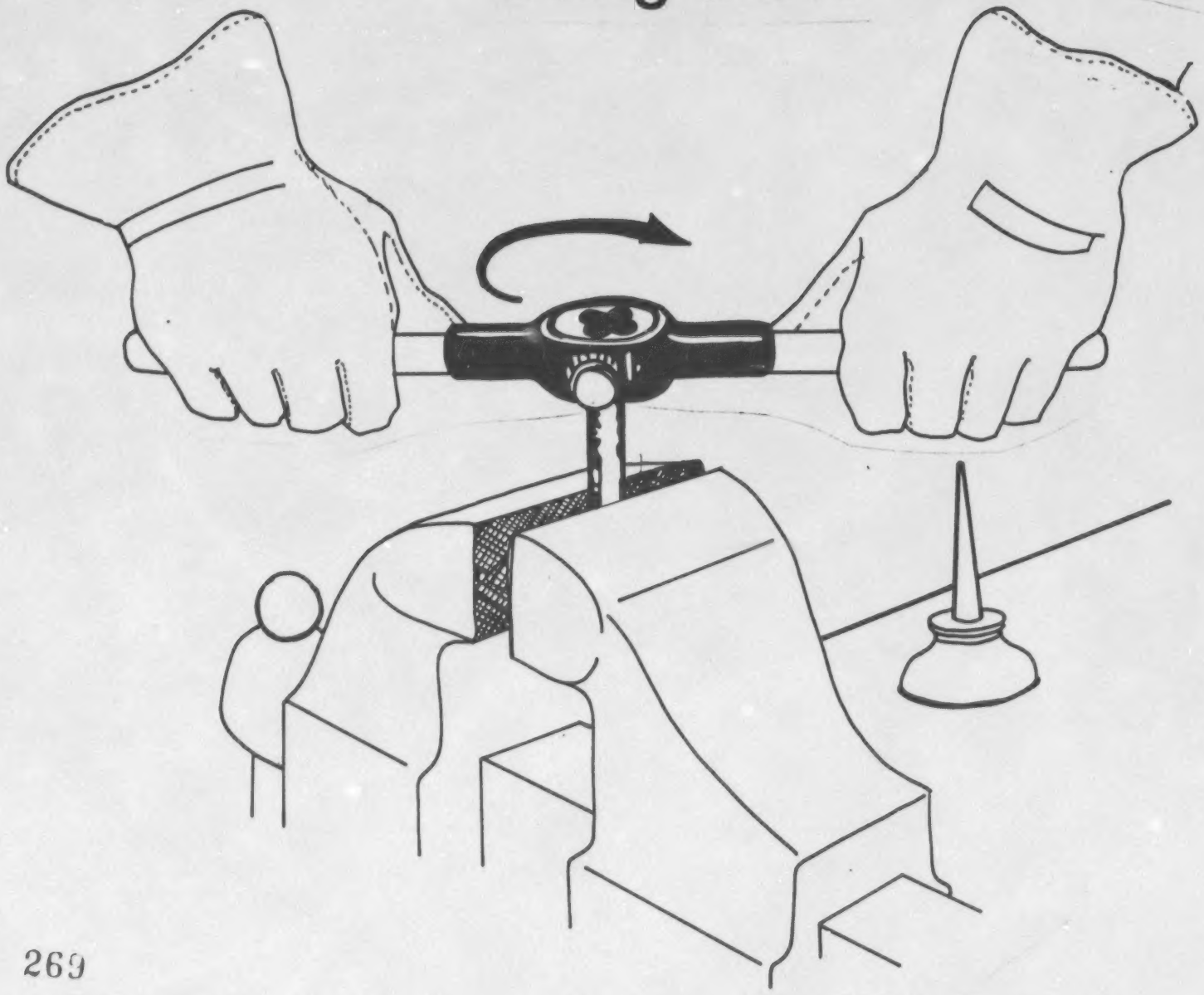


riveting pliers

Types of Taps



Using a Die



UNIT - COLD METAL WORK

SHOP DEMONSTRATION #1: Making a Small Shelf Bracket

Note: This is plan number 703 (Shelf Bracket A), which is available in pad form from the Instructional Materials Laboratory.

Objective: At the end of this demonstration, the student should be prepared to begin the shop exercise in making a small shelf bracket.

Tools Needed:

1. Hacksaw, with a blade with 24 teeth per inch
2. Rivet set
3. Adjustable end wrench
4. Drill press, with 3/16" and 3/8" drill bits
5. Length of 1/4" pipe or 1/2" rod (for bending template)
6. Mill bastard file
7. Ball-peen hammer
8. Steel square
9. Center punch

Materials Needed:

1. One each - 1/8" x 1" x 24 " hot rolled mild steel (HRMS)
2. Two each - 3/16" x 1/4" countersunk flat top soft iron rivets

Procedure:

Step 1: Demonstrate hacksawing to length. Saw the 24" blank into one 16 1/2" piece and one 6 3/4" piece. Use a file to square up the ends and/or round off sharp edges.

Step 2: Demonstrate how to lay out the bracket, marking drill holes, twists, and bends. Center punch each hole to be drilled.

Step 3: Demonstrate how to make the necessary bends and twists for the shelf brackets.

a) Twist the brace by placing the stock in the vise just below the bend. Place the adjustable wrench on the top of the stock and twist 1/2 turn.
b) Make the 90-degree bend in the long piece. Place the stock in the vise just below the bend, then bend with several blows of the hammer.
c) Make the 45-degree bends in the brace.
d) Roll the ends of the long piece by clamping and rolling around the piece of pipe (or rod).

Step 4: Demonstrate drilling and countersinking the holes. (Do not drill one hole in the end of the brace.)

Step 5: Demonstrate riveting the two pieces together with one rivet. Demonstrate squaring the bracket with a square, drilling the remaining hole, and setting the final rivet.

UNIT - COLD METAL WORK

SHOP EXERCISE #1: Making a Small Shelf Bracket

Objective: At the end of this exercise, the student should be able to perform the skills in making a small shelf bracket.

Tools Needed:

1. Hacksaw, with a blade with 24 teeth per inch
2. Rivet set
3. Adjustable end wrench
4. Drill press, with 3/16" and 3/8" drill bits
5. Length of 1/4" pipe or 1/2" rod (for bending template)
6. Mill bastard file
7. Ball-peen hammer
8. Steel square
9. Center punch

Materials Needed:

1. One each - 1/8" x 1" x 24 " hot rolled mild steel (HRMS)
2. Two each - 3/16" x 1/4" countersunk flat top soft iron rivets

Procedure:

Step 1: Hacksaw the 24" blank into one 16 1/2" piece and one 6 3/4" piece. Use a file to square up the ends and/or round off sharp edges.

Step 2: Lay out the bracket, marking drill holes, twists, and bends. Center punch each hole to be drilled. (Refer to Figure 1.)

Step 3: Make the necessary bends and twists for the shelf brackets.

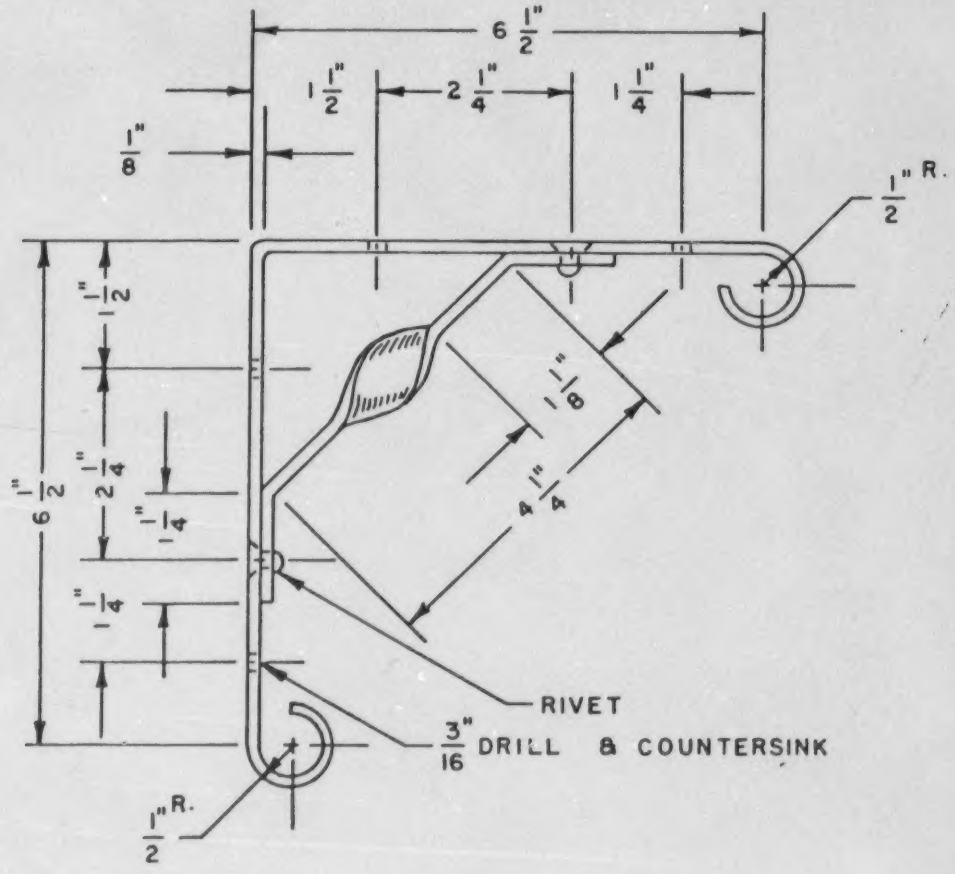
a) Twist the brace by placing the stock in the vise just below the bend. Place the adjustable wrench on the top of the stock and twist 1/2 turn.
b) Make the 90-degree bend in the long piece. Place the stock in the vise just below the bend, then bend with several blows of the hammer.
c) Make the 45-degree bends in the brace.

d) Roll the ends of the long piece by clamping and rolling around the piece of pipe (or rod).

Step 4: Drill all holes except one hole at the end of the brace. Countersink the holes for the two rivets in the long piece.

Step 5: Rivet the two pieces together with one rivet, then square the bracket with a square. Drill the remaining hole. Set the remaining rivet.

Small Shelf Bracket



Courtesy - C. Weston

Figure 1

NOTES TO THE TEACHER

Project Construction

There are 21 days built into this curriculum for project construction. When selecting the projects to be constructed by students during this time, the teacher should consider the cost of such projects, the usefulness of the projects in the area (that is, will there be a demand for these projects once they are constructed), that the projects will use the skills taught in previous lessons, and the level of ability of the students.

In addition, consideration should be given to the points which determine the best choice of a shop project (from Lesson 1 in the Materials Selection, Plan Reading, and Interpretation Unit). They are:

1. The need and/or usefulness of the project.
2. The skills needed to complete the project.
3. The level of difficulty of the project.
4. The availability of the tools and materials required for the project.
5. The time available for project construction.
6. The cost of the project.

Recommended projects for this curriculum include: (Each of these plans is available in pad form from the Instructional Materials Laboratory.)

Wood Projects	Metal Projects
Saw horse (Plan No. 852)	Metal gate (Plan No. 400 or 401)
Step ladder (Plan No. 108)	Picnic table (Plan No. 505)

UNIT - MATERIAL SELECTION, PLAN READING, AND INTERPRETATION

Lesson 1: How do I decide on the right project and plan for that project?

Objective: At the conclusion of this lesson, the student will be able to plan a shop project.

Study Questions:

1. **What determines the best choice of a shop project?**
2. **What steps should I follow when planning for my shop project?**

Reference:

1. Handout
   a. HO-1: Choosing Shop Projects and Planning Project Construction

UNIT - MATERIAL SELECTION, PLAN READING, AND INTERPRETATION

Lesson 1: How do I decide on the right project and plan for that project?

TEACHING PROCEDURES

A. Review

B. Motivation: Show pictures or slides of projects that have been built in the vocational agriculture shop to the students. Ask the students why projects are built in the shop. Reinforce the educational background of the project work. Inject the idea that this lesson will help each student to determine the best shop project for each individual.

C. Assignment: Have the students read HO-1.

D. Supervised Study

E. Discussion

1. Ask the students what determines the best choice of a shop project. List the suggestions on the board. Hand out examples of several shop plans suitable for the students to build. (NOTE: Each plan handed to the class should already have been screened as to its appropriateness for the class on each of the listed factors as well as the educational value and appropriateness for vocational agriculture students.) Talk through one or more of the plans in reference to each point.

   What determines the best choice of a shop project?

   1) The need and/or usefulness of the project.
   2) The skills needed to complete the project.
   3) The level of difficulty of the project.
   4) The availability of the tools and materials required for the project.
   5) The time available for project construction.
   6) The cost of the project.

2. Ask the students what steps they should follow when planning for shop projects. Tell the students what materials will be available from the vocational agriculture shop or FFA and which materials they will need to obtain elsewhere. List local sources for these materials.

   What steps should I follow when planning for my shop project?

   1) Choose the project.
   2) Draw plans if plans are not available.
   3) Plan the construction of the project.
      a) Find a logical starting point, such as cutting smaller pieces of large stock first.
      b) Group operations together, such as doing all crosscutting of wood at the same time.
      c) Develop a cutting list for materials.
      d) Organize a construction schedule for the project.

4) Draw up a bill of materials.
5) Obtain the necessary materials and have them on hand when needed.

F. Other Activities

G. Summary

When selecting a shop project and planning for that project, a student should:

1. Consider the need, the skills needed, the level of difficulty, the availability of the necessary tools and materials, the time needed, and the cost of the projects being considered.
2. Draw plans if plans are not available, plan the construction, draw up a bill of materials, and obtain the needed materials.

H. Answers to Evaluation

1. Any four of the following:
   a. The need and/or usefulness of the project.
   b. The skills needed to complete the project.
   c. The level of difficulty of the project.
   d. The availability of the tools and materials required for the project.
   e. The time available for project construction.
   f. The cost of the project.
2. F
3. T

UNIT - MATERIAL SELECTION, PLAN READING AND INTERPRETATION

Lesson 1: How do I decide on the right project and plan for that project?

EVALUATION

1. List four factors which determine the best choice of a shop project.

   a.

   b.

   c.

   d.

T F 2. Grouping operations together such as crosscutting lumber during construction seldom saves enough time to be worthwhile.

T F 3. Developing a cutting list will help to prevent waste of materials and extra costs.

CHOOSING SHOP PROJECTS AND PLANNING PROJECT CONSTRUCTION

Have you ever started to make something, then run out of time before being able to finish? Would you have been able to finish if you had organized the job differently? Organizing the job is one of several different things you must do to get the job completed on time. This lesson will look at how to choose a shop project and how to plan the project to get it completed in the time available.

Choosing a Shop Project

A number of factors will determine the best choice of a shop project. First, consider the need for the project or its usefulness. Is there a need for this project at your home? Would this project be useful to save time or labor? A project which is not needed or would not prove useful would be a poor choice.

Next, look at the skills needed to complete the project. Will the project provide practice on those skills you already know, or will you need to learn additional skills befor starting the project?

Consider the level of difficulty of the project. A project which would require the learning of a large number of additional skills would probably be a poor choice.

Check the availability of the tools and materials required for the project. Will special tools be required which are not available? Can you obtain all of the materials or will some require special ordering? Tools and/or materials which are not available may rule out some choices of shop projects.

Find out how much time is available to build the project. Some projects may be so large or so difficult that they cannot be done within the time allotted ruling them out as possible choices.

Finally, consider the cost of the project. Some projects may require expensive materials so that the cost of the project is beyond your reach. Others may be so large that the total cost is too expensive.

Consider every project on each criterion. Some projects will rate higher on some criteria but lower on others. Choose the project that rates best overall.

Planning Shop Projects

After the project has been chosen, it will be necessary to draw up plans for the project if plans are not already available. (More information on drawing plans is contained in Lesson 2.)

Plans are a means of communication between the planner and the builder. In addition, putting the plan down on paper may help you to see or anticipate problems you may face in construction that you may not see if the plan is in your head. If you are using a prepared plan, look carefully at the plan. Are there any ways that the plan can be improved?

Next, plan for the construction of the project. Find a logical starting point. For many wood projects, cutting large pieces of lumber into the required lengths would be the place to start. Plan to group operations together as much as possible to make efficient use of time and reduce the time required for machine setup. For example, plan to do all the crosscutting operations together, then change the machine to do the ripping operations.

Develop a cutting list for materials. Know which lengths will be cut from each piece of stock. For example, if one 2 x 4 that is 6' 9" long and five 2 x 4's that are 2' 9" long are needed for a project, then, one 10' long and one 12' long 2 x 4 can be ordered for the project. The cutting list would show that the 10' board would provide the 6' 9" piece and one 2' 9" piece, and the 12' board would be cut into four 2' 9" pieces. Small pieces would be left over from each board.

Note that if the 6' 9" piece were to be cut from the 12' board, the remaining lumber would not be sufficient to cut all the five 2' 9" pieces and another 2 x 4 would have to be obtained to cut the final 2' 9" piece. Making out a cutting list then following it would help to prevent this extra expense and waste of lumber.

Organize a construction schedule for the project. Plan a step-by-step procedure for building the project. Analyze this procedure to determine when various supplies will be needed. Insert this information into the procedures. This will help to avoid delays in construction when these procedures are followed as the project is built.

Now draw up a bill of materials for the project if one is not available. (More information on bills of material is contained in Lesson 3.)

Obtain the necessary materials for the project and have them ready as they are needed in the construction process.

Following these steps should help you plan your shop project so that it can be completed in the time available.

Summary

When selecting a shop project, consider a number of factors, including the need or usefulness of the project, the skills needed, the level of difficulty, the availability of the necessary tools and materials, the time needed, and the cost of each project. Evaluating each project for these factors will help you to select the best project for you. After the project has been selected, a plan for the project will need to be drawn up if prepared plans are not already available. Next, plan the construction carefully to make maximum use of the time and materials available. A bill of materials can then be drawn up and the needed materials can be obtained so that the project can start and finish on time.

Credit

Planning Project Construction, Bear, Hamilton, and Mann, pp. 3-[illegible], 39.

UNIT - MATERIAL SELECTION, PLAN READING, AND INTERPRETATION

Lesson 2: How do I make and read working drawings?

Objective: At the conclusion of this lesson, the student will be able to make and read working drawings.

Study Questions:

1. **What is a working drawing?**
2. **What are some common symbols used in drawings and plans?**
3. **What views should be included in a working drawing?**
4. **How do I dimension a working drawing?**

References:

1. Modern Agricultural Mechanics, Wakeman, Chapter 1.
2. Shopwork On the Farm, Jones, Chapter 2.
3. Transparency Masters
   a. TM-1: Common Drawing Symbols
   b. TM-2: Dimensioning a Drawing
4. Handout
   a. HO-2: Common Drawing Symbols

UNIT - MATERIAL SELECTION, PLAN READING, AND INTERPRETATION

Lesson 2: How do I make and read working drawings?

TEACHING PROCEDURES

A. Review of the previous lesson.

B. Motivation: Show a small engine carburetor (or some other object which has hidden parts) to the students. Ask the students if they could manufacture an identical carburetor from snapshots of that one, assuming they had the tools and skills to do so. Guide the discussion to the conclusion that plans and working drawings are a means of communication between the planner and the builder.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students what a working drawing is.

What is a working drawing?

1) A rough outline of an object, usually not drawn to scale, with various views and dimensions.

2. Hand out HO-2 to the students. Show TM-1 to the students. Ask the students to identify some common symbols used in drawings and plans.

What are some common symbols used in drawings and plans?

1) Insulation: Loose Fill or Batts (Refer to TM-1 and HO-2.)
2) Insulation: Boards or Quilts
3) Structural Concrete
4) Concrete Block
5) Steel, Iron
6) Finished Wood
7) Rough Wood
8) Stud Wall and Partition
9) Common Brick
10) Glass Sheet and Plate
11) Door

3. Ask the students what views should be included in a working drawing.

What views should be included in a working drawing?

1) For simple, flat objects an outline is all that is necessary.

2) For most objects a top view, an end view, and a side view will be adequate.
3) Use other views, sectional views, or details if the top, end, and side views do not reveal hidden details or to highlight construction details.
4) In general, use as few drawings as possible as long as all of the essential information is covered.

4. Show TM-2 to the students. Ask the students how to dimension working drawings.

How do I dimension a working drawing?

1) Place each dimension so that there is no confusion about which detail is described.
2) Do this through the use of extension lines, dimension lines, and leaders. (Refer to TM-2.)
3) Leave gaps for the figures or place them at the end of leaders.
4) Place figures so that they can be read from the bottom or the right side of the drawing for easier reading.
5) Avoid crowding the figures into small areas.

F. Other Activities

If time allows, assign the students to draw a working drawing of a small shop project. If the students have no plan for their choices of shop projects, they should draw up the plans at this time.

G. Summary

When making working drawings, the student should:

1. Use common symbols to identify objects and parts of the drawing.
2. Include views that will identify each detail of the object being drawn.
3. Use dimension lines, extension lines, and leaders in conjunction with figures to describe each detail.

H. Answers to Evaluation

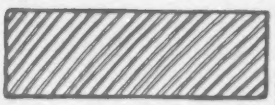
1. a. Steel or Iron
   b. Finished Wood
   c. Structural Concrete
2. F
3. T

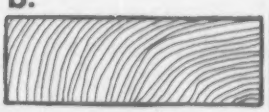
UNIT - MATERIAL SELECTION, PLAN READING AND INTERPRETATION

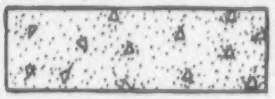
Lesson 2: How do I make and read working drawings?

EVALUATION

1. Identify these symbols used in drawings.

a. 

b. 

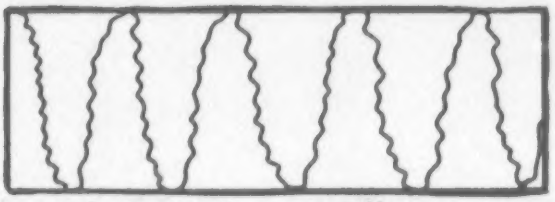
c. 

a. _____ b. _____ c. _____

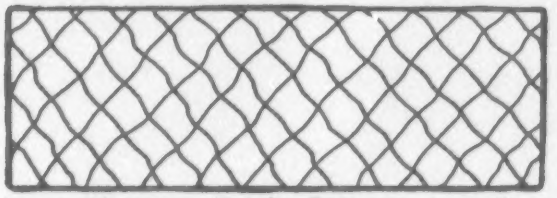
T F 2. Every drawing should include a top, a side, and an end view.

T F 3. Figures should be placed on the drawing so that they can be read from the bottom or the right of the drawing for easier reading.

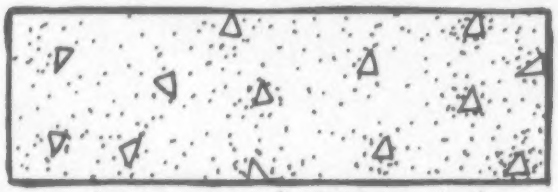
Common Drawing Symbols



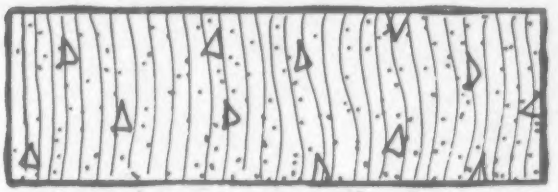
Insulation: Loose Fill or Batts



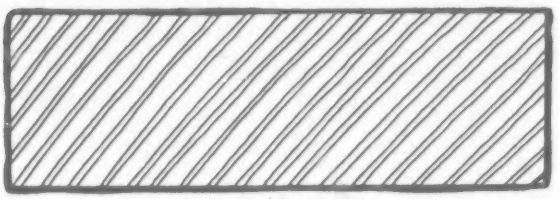
Insulation: Boards or Quilts



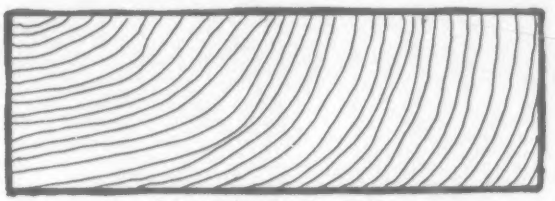
Structural Concrete



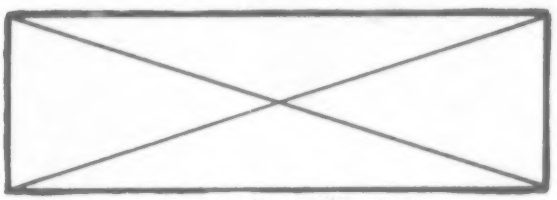
Concrete Block



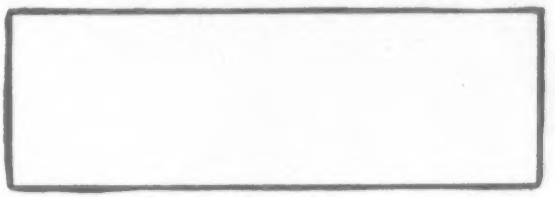
Steel, Iron



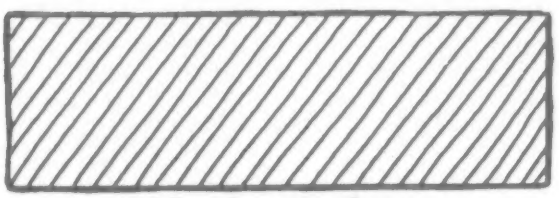
Finished Wood



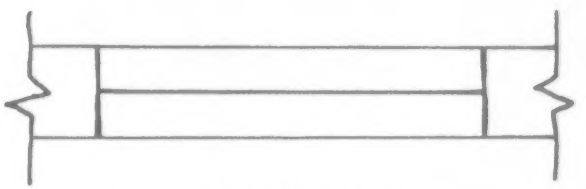
Rough Wood



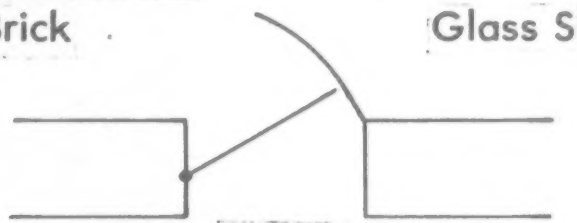
Stud Wall and Partition



Common Brick



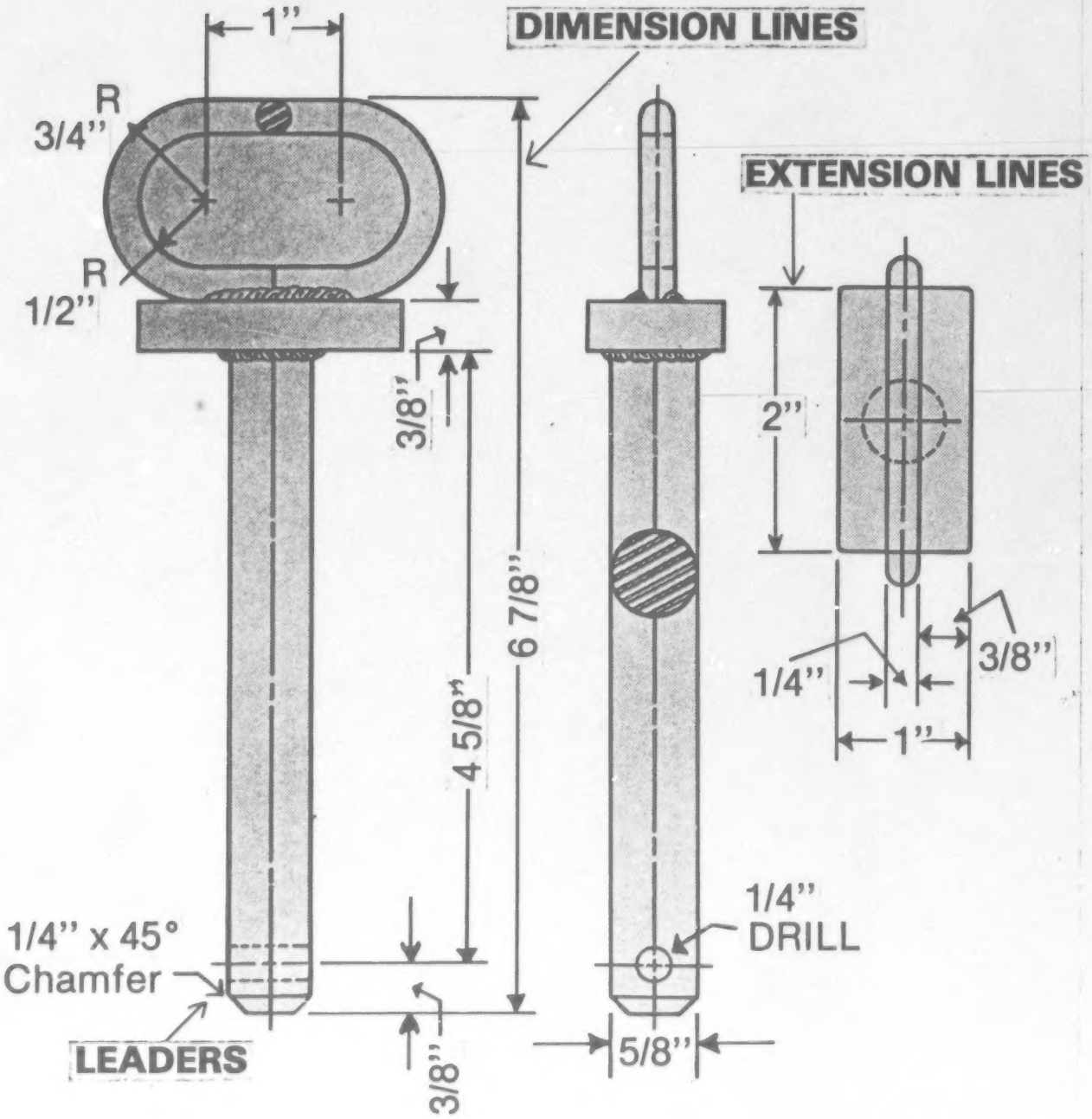
Glass Sheet and Plate



Door

Dimensioning A Drawing

TM-2



Bill of Material:

1 pc mild steel 3/4" round
5" long
1 pc bar 3/8" x 1" x 2" long
1 pc rod 1/4" x 6" long

Drawbar Pin

Scale: 12" = 1' 10"

UNIT - MATERIAL SELECTION, PLAN READING, AND INTERPRETATION

Lesson 3: How do I develop a bill of materials and specifications?

Objective: At the end of this lesson, the student will be able to develop a bill of materials and specifications.

Study Questions:

1. **What are the grades of lumber and plywood?**
2. **What must I specify when ordering building materials?**
3. **What are the different shapes of steel used in project construction?**
4. **How do I make out a bill of materials?**

References:

1. Modern Agricultural Mechanics, Wakeman, Chapter 1.
2. Shopwork on the Farm, Jones, Chapter 2.
3. Transparency Masters
   a. TM-3: Sample Plywood Grade Stamps
   b. TM-4: Shapes of Mild Steel
4. Handouts
   a. HO-3: Grades of Lumber for Farm Construction
   b. HO-4: Grades of Plywood for Agricultural Use
   c. HO-5: Shapes of Mild Steel
   d. HO-6: Making Out a Bill of Materials

UNIT - MATERIAL SELECTION, PLAN READING, AND INTERPRETATION

Lesson 3: How do I develop a bill of materials and specifications?

TEACHING PROCEDURES

A. Review of the previous lesson.

B. Motivation: Pass two or three examples of various grades of softwood lumber around the classroom. Ask the students if there would be any differences in the physical properties of buildings made from each grade. Ask the students if one grade would be stronger than another. Ask the students for examples where a good surface appearance would be needed.

C. Assignment

D. Supervised Study

E. Discussion

1. Hand out HO-3 to the students. Ask the students what the grades of lumber are. Hand out HO-4 to the students. Ask the students what the veneer grades of plywood are and which grades of plywood are used in agriculture. Show TM-3 to the students. Ask the students to identify the parts of a plywood grade stamp.

What are the grades of lumber and plywood?

1) Ungraded or native lumber.
2) Commercial lumber - either hardwood or softwood.
3) Most commercial lumber in farm buildings is softwood lumber graded under the American Softwood Lumber Standard (ASLS).
   a) Rough lumber - has not been dressed (surfaced) but has been sawed, edged, and trimmed on each longitudinal surface.
   b) Dressed (surfaced) lumber - has been planed to smooth surfaces and uniform size, specified by the number of sides and edges surfaced, such as S1S1E (surfaced 1 side and 1 edge).
   c) Worked lumber
      (1) Matched lumber - has been worked to a tongue and groove.
      (2) Shiplapped lumber - has been worked or rabbeted on both edges of each piece to insure a close fit when put together.
      (3) Patterned lumber - has been further worked to a pattern or molded form.
4) Grades of lumber. (Refer to HO-3.)
   a) Dimension lumber (2"-5" thick x 2" wide or more).
      (1) Structural light framing grades - Select Structural (SEL STR), No. 1, No. 2, or No. 3.

(2) Light framing grades - Construction (CONST), Standard (STD), Utility (UTIL), or Economy (ECON).
(3) Stud grade.
(4) Structural joist and plank grades - Select Structural (SEL STR), No. 1, No. 2, or No. 3.
(5) Appearance framing grade - A

b) Grades of timbers (5" or more in the smallest dimension) - Select Structural (SEL STR), No. 1, No. 2, or No. 3.
c) Grades of boards (up to 1 1/2" thick, 2" wide or more) -Select Merchantable (SEL MER) or No. 1, Construction (CONST) or No. 2, Standard (STD) or No. 3, Utility (UTIL) or No. 4, or Economy (ECON) or No. 5.
d) Grades for finish or selects (up to 1 1/2" thick, 2" wide or more) - B and Better (B & BTR), C, or D.

5) Veneer grades used in plywood manufacture. (Refer to HO-4.)
a) N and A
b) B
c) C Plugged
d) C
e) D

6) Grades of plywood for agricultural applications. (Refer to HO-4.)
a) Appearance grades - A-A EXT, A-C EXT, or B-C EXT.
b) Engineered grades - C-D INT, C-C EXT, C-C PLUGGED EXT, or STRUCTURAL I and II C-D INT and C-C EXT.
c) Specialty grades - HDO EXT, MDO EXT, 303 SIDING EXT.

7) Sample grade stamps. Information on grade stamps includes:
a) Grade of veneer on the panel face. (Refer to TM-3.)
b) Grade of veneer on the panel back.
c) Species group number - indicates strength properties of the wood used, from 1 (strongest species) to 5.
d) Type of plywood - interior or exterior.
e) Identification index - indicates the support spacing for roofing (first number) or flooring (second number).
f) Product standard number.
g) Mill number where plywood was manufactured.

2. Ask the students what must be specified when ordering building materials.

What must I specify when ordering building materials?

1) Lumber - specify grade, nominal dimensions, and standard lengths. Standard lengths of dimension lumber are 8', 10', 12', 14', and 16'.
a) Lumber is priced by the board foot.
b) The number of board feet is figured using the formula:

$$\text{Board Feet} = \frac{\text{number of pieces x inches thick x inches wide x feet long}}{12}$$

c) Example: If lumber is priced at 40 cents per board foot, ten 2 x 6's 12 feet long would cost $48.

$$\frac{10 \text{ pcs} \times 2 \times 6 \times 12}{12} = 120 \text{ board feet @ } 40¢ = \$48$$

2) Lumber less than 1 inch thick nominally is usually sold by the square foot.
3) Roofing is sold by the square (1 square - 100 square feet); one bundle of shingles contains 1/3 of a square.
4) Hardware cloth and screening are sold by the running foot.

3. Hand out HO-5 to the students. Show TM-4 to the students. Ask the students to identify the various shapes of steel used in project construction.

What are the different shapes of steel used in project construction?

1) Rounds - specify external diameter (ED) of the round; standard length is 20 feet. (Refer to TM-4 and HO-5.)
2) Square tubing - specify the width (W) and the thickness (T) of the metal from which the tube is formed; standard length is 20 feet.
3) Flats and strips - specify the width (W) and thickness (T); standard length is 20 feet.
4) Angle iron - specify the width of each leg (W) and the thickness (T); standard length is 20 feet.
5) Channel iron - specify the depth of the channel (CD) and the width of the flange (F); standard length is 20 feet.
6) Zee bar - specify the thickness (T), stem height (S), and width of the flange (F); standard length is 20 feet.
7) Structural I-beams - specify stem height (S) of beam; standard length is 20 feet.
8) Wide flange I-beams - specify stem height (S) and width of flange (F); standard length is 20 feet.
9) Tee bars - specify width of flange (F), stem height (S), and thickness (T); standard length is 20 feet.
10) Pipe - sold by the inside diameter (ID) comes in black or galvanized; commonly comes in the standard (schedule 40) or double wall (schedule 80); standard length is 21 feet.

4. Ask the students how to make out a bill of materials.

How do I make out a bill of materials?

1) A bill of materials is a list of the materials, usually in table form, indicating the use of each piece, the number of pieces, and the size, length, kind, etc.
2) Start with items to be used first.
3) Include everything needed including nails , paint, and hardware.
4) Give the amounts needed in standard stock sizes.

F. Other Activities

Additional activities appropriate for this lesson would include:

1. Drawing up a bill of materials for a designated shop project. (If the students have no bills of materials for their choices of shop projects, they should draw up their bills of materials at this time.)

2. Completing the bill of materials for the feed bunk on HO-6. (NOTE: Since the scale is approximate, students should use the measurements listed to draw up the bill of materials and not try to scale the drawing with an architect's scale.)

Answer to HO-6:

Bill of Materials

2 - 2" x 6" x 8' (runners)
1 - 4" x 4" x 8' (legs)
3 - 2" x 4" x 8' (end braces and side braces)
1 - 2" x 4" x 10' (side brace and center support)
3 - 2" x 8" x 8' (sides and ends)
5 - 1" x 8" x 8' (floor)

G. Summary

When developing a bill of materials and specifying materials, a student should:

1. Prepare a detailed listing of all materials needed including the use of each piece, the number of pieces, the size, and lengths in standard stock sizes.
2. Specify the type and grade of lumber needed.
3. Specify the shape of steel to be used.

H. Answers to Evaluation

1. T
2. T
3. T
4. T
5. T
6. F
7. T
8. F

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Lesson 3: How do I develop a bill of materials and specifications?

EVALUATION

The following statements are either true or false. Circle a T if the statement is true; circle an F if the statement is false.

T F 1. Softwood lumber specified as S4S has been surfaced on all sides.

T F 2. Lumber that is 1 inch thick nominally or larger is priced by the board foot.

T F 3. Standard length for pieces of new black pipe is 21 feet.

T F 4. A piece of 2 x 6 that is one foot long contains one board foot.

T F 5. One square of shingles will cover 100 square feet of roof.

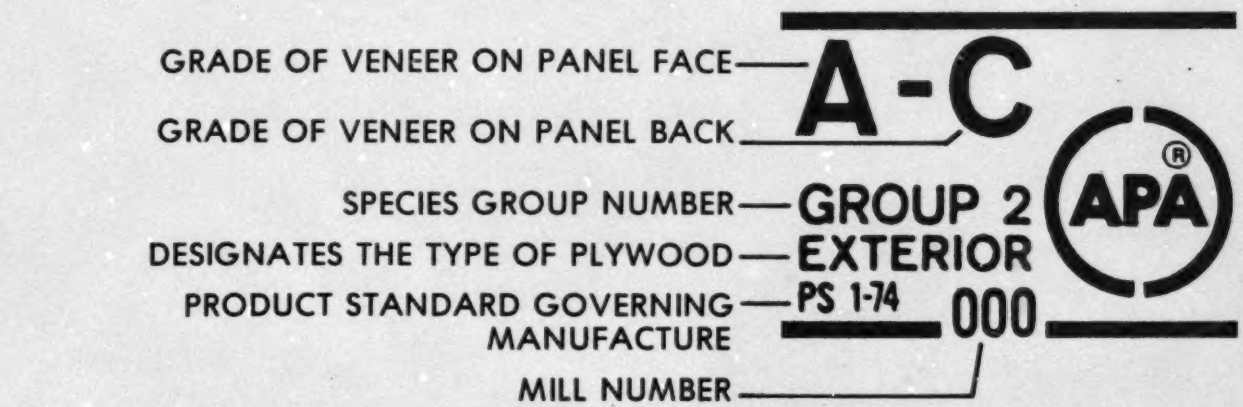
T F 6. Plywood graded A-B INT would be suitable for building a hay feeder for outdoor use.

T F 7. Boards graded CONST are of higher quality and are generally more expensive than those graded UTIL.

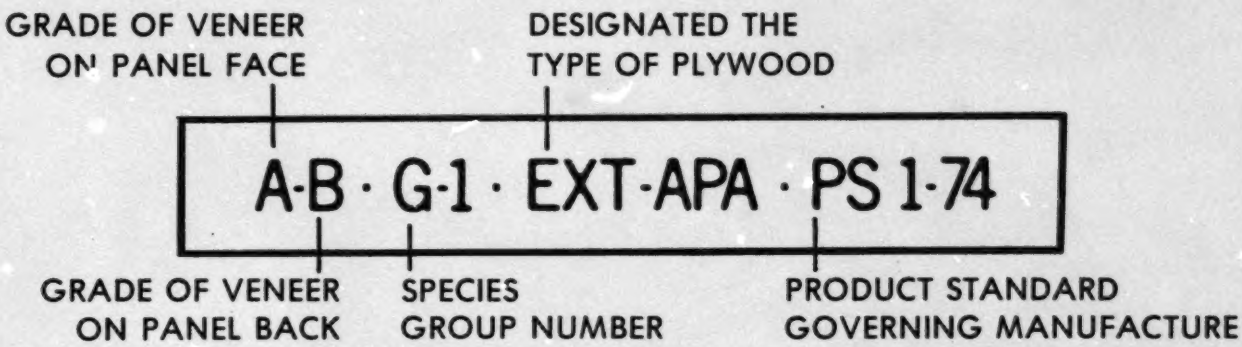
T F 8. Knotholes in plywood veneer must be plugged to meet the standards for grade D.

Sample Plywood Grade Stamps TM-3

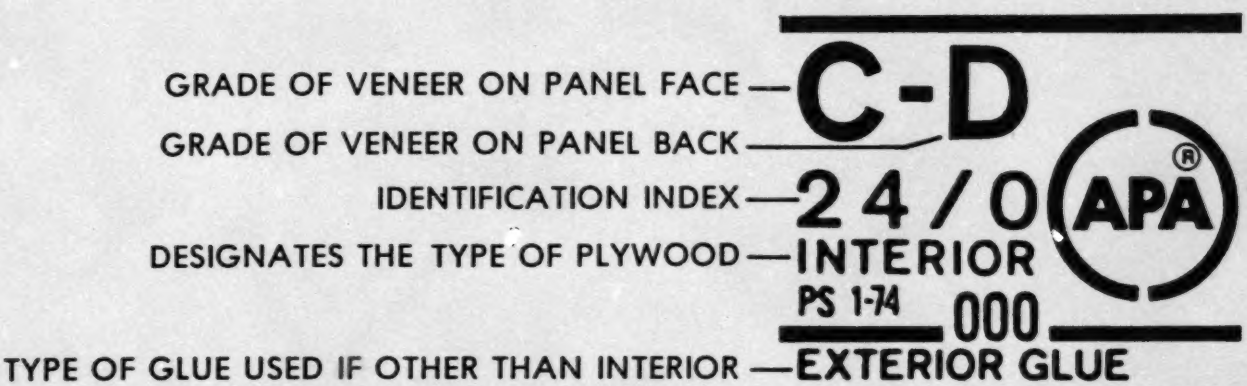
TYPICAL SANDED PANEL BACK-STAMP



TYPICAL EDGE-STAMP


GRADE OF VENEER ON PANEL FACE
DESIGNATED THE TYPE OF PLYWOOD
A-B · G-1 · EXT-APA · PS 1-74
GRADE OF VENEER ON PANEL BACK
SPECIES GROUP NUMBER
PRODUCT STANDARD GOVERNING MANUFACTURE

TYPICAL UNSANDED PANEL BACK-STAMP

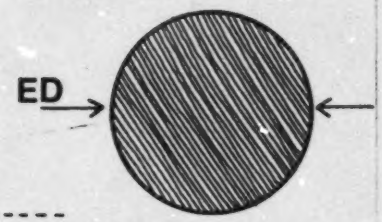


From **Structures and Environment Handbook, Midwest Plan Service.**

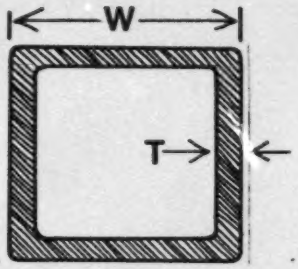
Shapes of Mild Steel

TM-4

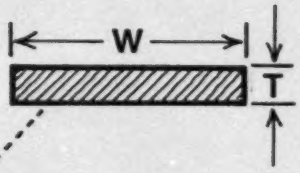
1. Round



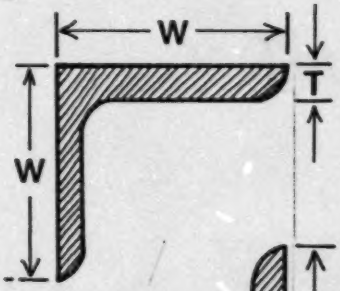
2. Square Tubing



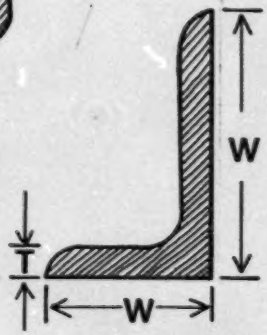
3. Flats, Strips



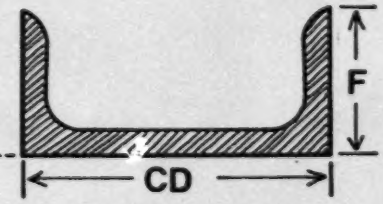
4. Equal Leg Angle Iron



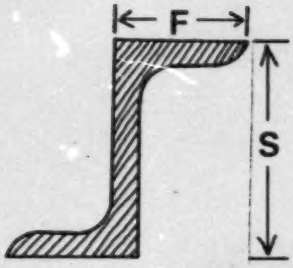
5. Unequal Leg Angle Iron



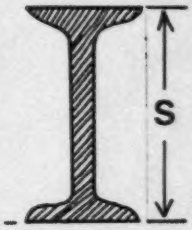
6. Channel Iron



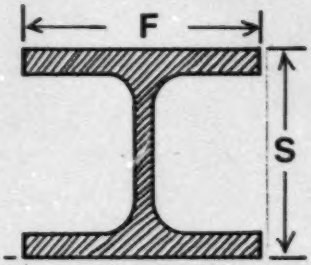
7. Zee Bar



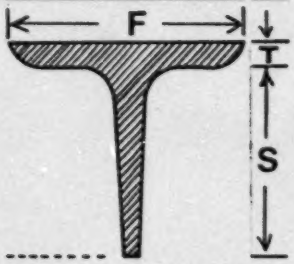
8. Standard I-Beam



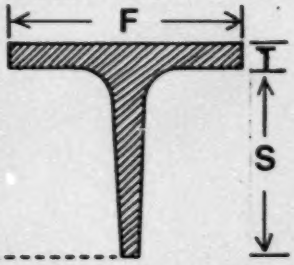
9. Wide Flange I-Beam



10. Structural Tee



11. Tee



12. Pipe

Grades of Lumber for Farm Construction

HO-3

Classification	Grades	Description or Use
Dimension		
2" to 5" thick 2" or more wide	**Structural Light Framing** (2"-4" thick, 2"-4' wide)	
	Select Structural	• For engineered use where higher strength is needed.
	No. 1	• Use where high strength and stiffness and good appearance are needed.
	No. 2	• Use about the same as SEL STR, a little lower in quality.
	No. 3	• Recommended for most general construction uses.
		• Use for general construction where appearance is not a factor.
	Light Framing (2"-4" thick, 2"-4" wide)	• Provides good appearance where high strength and high appearance are not needed.
	Construction	• Recommended and widely used for general framing purposes.
	Standard	• About same uses as CONSTRUCTION but a little lower in quality.
	Utility	• Used for studding, blocking, plates, etc. where economy and good strength are desired.
	Economy	• Suitable for crating, bracing and temporary construction.
	Studs (2"-4" thick, 2"-4" wide) Stud	• Only one grade; suitable for all stud uses.
	Structural Joints & Planks (2"-4" thick, 6" & wider)	• For engineering applications.
	Select Structural	• Use where high strength and stiffness and good appearance are needed.
	No. 1	• Use about same as SEL STR; a little lower quality.
	No. 2	• Recommended for most general construction use.
	No. 3	• For use in general construction where appearance is not a factor.
	Appearance Framing (2"-4" thick, 2" & wider) A	• Use exposed in housing and light construction for high strength and finest appearance.
Timbers 5" or more in least dimension	Select Structural	• Use where superior strength and good appearance are needed.
	No. 1	• Similar uses to SEL STR; a little lower in quality.
	No. 2	• Recommended for general construction.
	No. 3	• Use for rough general construction.
Boards up to 1½" thick, 2" or more wide		• Graded for suitability for use in construction.
	SEL MER or 1	• Use in housing and light construction for exposed paneling, shelving, etc.
	CONST 2	• Use for subfloors, roof sheathing, etc.
	STD 3	• Used about the same as #2 but a little lower in quality.
	UTIL 4	• Combines usefulness and low cost for general construction purposes.
	ECON 5	• Use for low grade sheathing, crating and bracing.
Finish or Selects up to 1½" thick, 2" or more wide		• Graded on basis of appearance.
	B & BTR	• Nearly clear with only minor defects; suitable for natural finish.
	C	• More and larger defects than B & BTR but suitable for paint finish.
	D	• A little lower in quality than C but still suitable for paint finish.

From **Structures and Environment Handbook, Midwest Plan Service.**

Grades of Plywood for Agricultural Use

HO-4

	Use these terms when you specify	Description and Most Common Uses	Veneer Grade			Most Common Thicknesses (Inch) (3)					
			Face	Back	Inner Plies	1/4	5/16	3/8	1/2	5/8	3/4
APPEARANCE (1)	A-A EXT (2) (4)	Use where the appearance of both sides is important. Fences, built-ins, signs, cabinets, commercial refrigerators, tanks and ducts.	A	A	C	√		√	√	√	√
	A-C EXT (2) (4)	Exterior use where the appearance of only one side is important. Sidings, soffits, fences, structural uses, truck lining and farm buildings. Tanks, commercial refrigerators.	A	C	C	√		√	√	√	√
	B-C EXT (2) (4)	An outdoor utility panel for farm service and work buildings, truck linings, containers, tanks, agricultural equipment.	B	C	C	√		√	√	√	√
ENGINEERED	C-D INT w/ext glue (2)	A utility panel for use where exposure to weather and moisture will be limited.	C	D	D		√	√	√	√	√
	C-C EXT (2)	Unsanded grade with waterproof bond for subflooring and roof decking, siding on service and farm buildings. Backing, crafting, pallets and pallet bins.	C	C	C		√	√	√	√	√
	C-C PLUGGED EXT (2)	For refrigerated or controlled atmosphere rooms. Also for pallets, fruit pallet bins, tanks, truck floors and linings. Touch-sanded.	C Plgd	C	C	√		√	√	√	√
	STRUCTURAL I & II C-D INT & C-C EXT	For engineered applications in farm construction. Unsanded. For species requirements see (4).	C	C or D	C or D		√	√	√	√	√
SPECIALTY	HDO EXT (2) (4)	Exterior type High Density Overlay plywood with hard, semi-opaque resin-fiber overlay. Abrasion resistant. Painting not ordinarily required. For concrete forms, signs, acid tanks, cabinets, counter tops and farm equipment.	A or B	A or B	C (5)		√	√	√	√	√
	MDO EXT (2) (4)	Exterior type Medium Density Overlay with smooth, opaque resin-fiber overlay, heat-infused to one- or both panel faces. Ideal base for paint. Highly recommended for siding and other outdoor applications. Also good for built-ins and signs.	B	B or C	C		√	√	√	√	√
	303 SIDING EXT inc. Texture 1-11 (2) (7)	Grade designation covers proprietary plywood products for exterior siding, fencing, etc. with special surface treatment such as V-groove, channel grove striated, brushed, rough-sawn.	(6) C	C	C			√	√	√	√

Notes:

(1) Sanded both sides except where decorative or other surfaces specified.
(2) Available in Group 1, 2, 3, 4, or 5 unless otherwise noted.
(3) Standard 4 X 8 panel sizes other sizes available.
(4) Also available in STRUCTURAL I (all plies limited to Group 1 Species) and II (limited to Groups 1, 2, and 3).
(5) Or C Plugged.
(6) C or better for 5-plies; C Plugged or better for 3-ply panels.
(7) Stud spacing is shown on grade stamp.

Veneer Grades

N and A Highest grade level. No knots, restricted patches. Use N for a natural finish or paintable surface.

B Solid surface. Small round knots. Patches and round plugs are allowed. Most common use is in Plyform, for concrete forms.

C Plugged Special improved C grade used in UNDERLAYMENT.

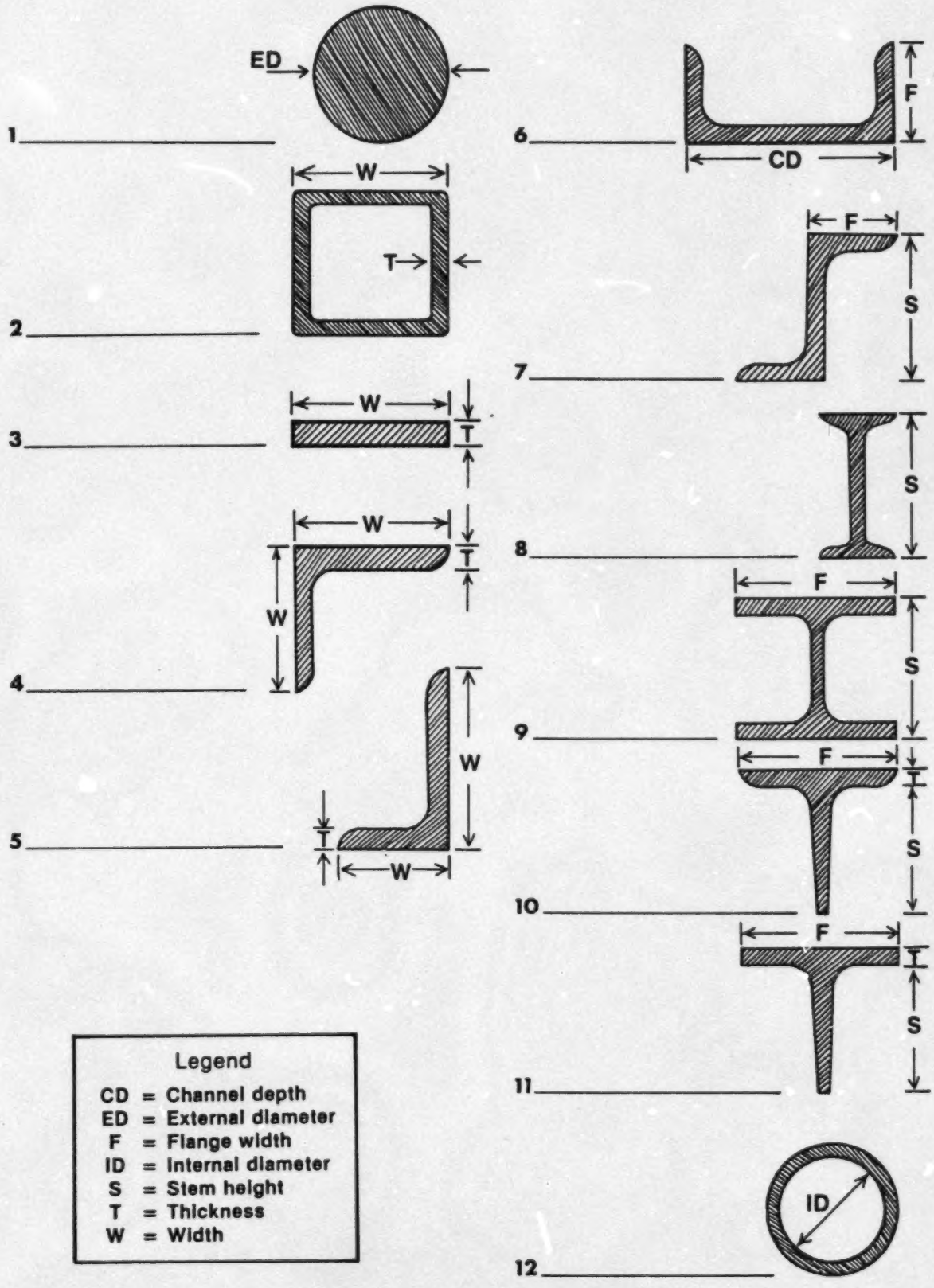
C Small knots, knotholes, patches. Lowest grade allowed in Exterior type plywood. For sheathing faces and inner plies in Exterior panels.

D Larger knots, knotholes, some limited white pocket in sheathing grades. For inner plies and backs in interior panels.

From: **Structures and Environment Handbook, Midwest Plan Service**

Shapes of Mild Steel

HO-5

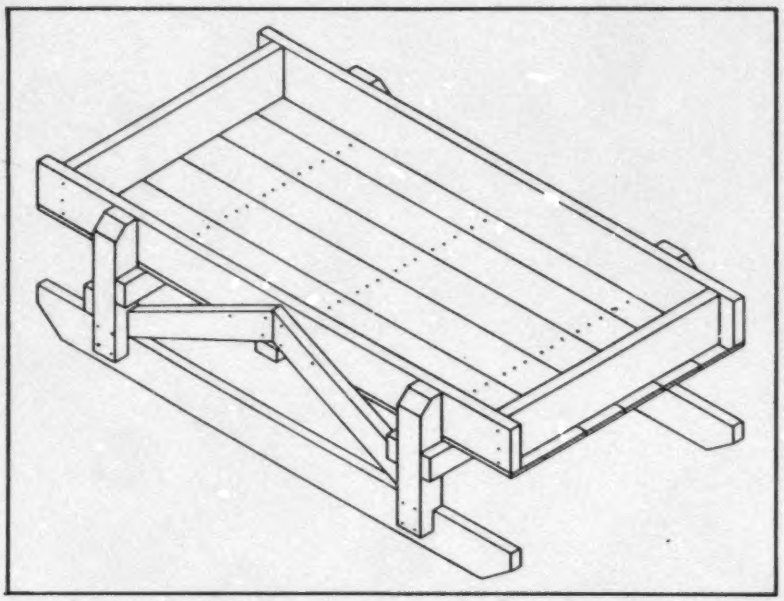


Legend

CD = Channel depth
ED = External diameter
F = Flange width
ID = Internal diameter
S = Stem height
T = Thickness
W = Width

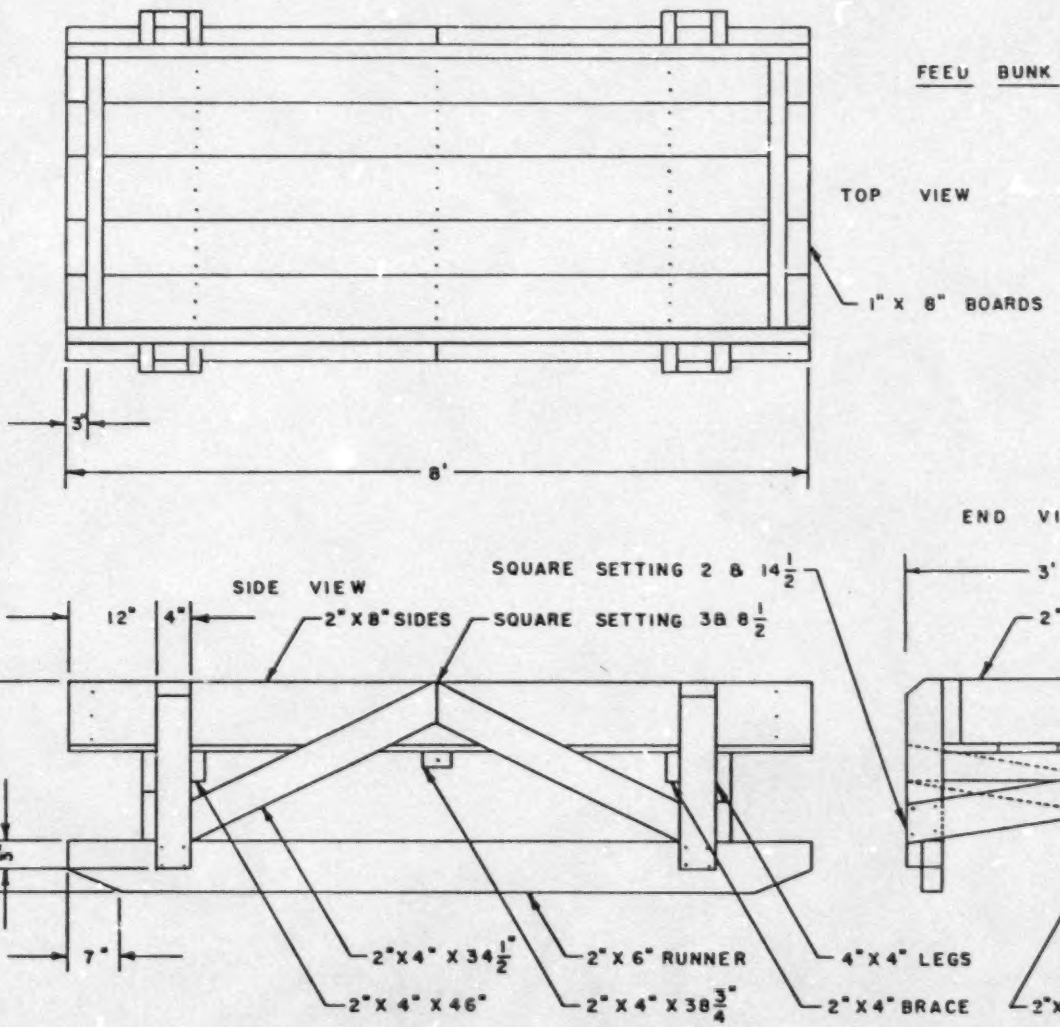
Making Out a Bill of Materials HO-6

Instructions: Draw up a bill of materials for the feed bunk pictured below.



FEED BUNK

App. Scale - 3/8"=1'-0"

Used- Courtesy- C.Weston

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